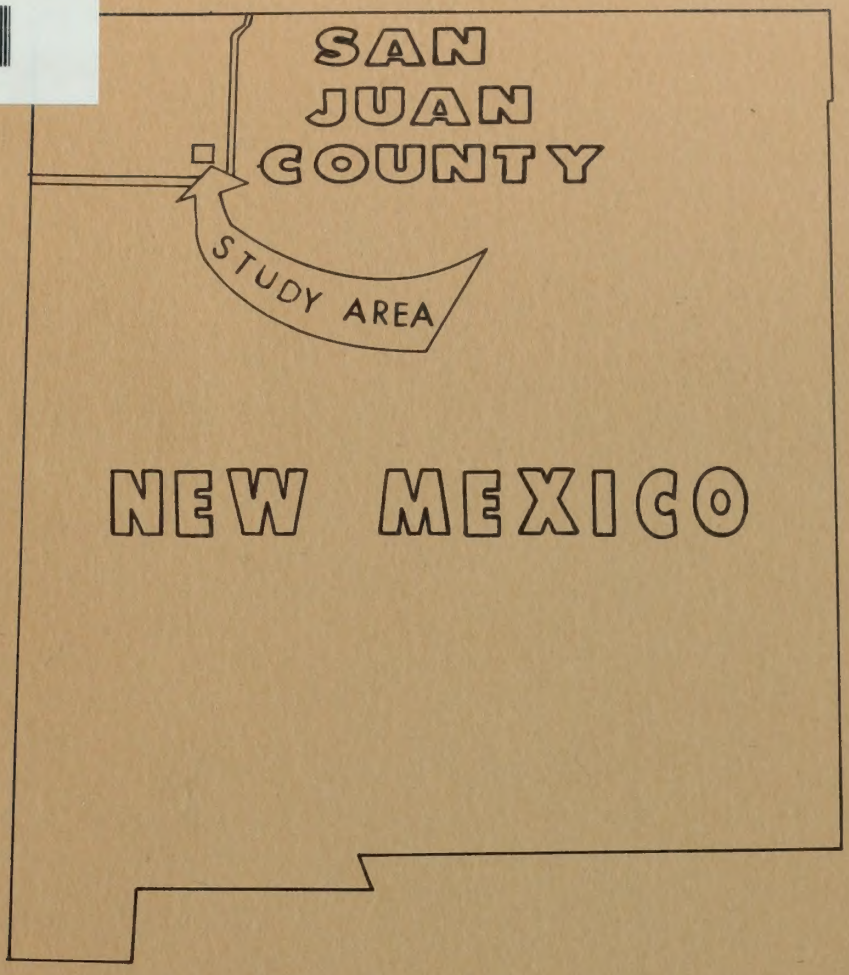
BLM LIBRARY
88018702



RESOURCE AND POTENTIAL RECLAMATION EVALUATION

KIMBETO STUDY AREA

REPORT NO. 17-77

U.S. Department of the Interior

Bureau of Land Management —— Bureau of Reclamation —— Geological Survey

September 1981

Kimbeto Study Area Report
Published September 1981

The Federal Coal Management Program has been designed as an interagency cooperative effort to meet national energy objectives.

"Kimbeto" Study Area Report was prepared through the efforts of the U.S. Department of Interior, principally the Bureau of Land Management, Geological Survey, and Bureau of Reclamation. The study effort began in 1977 and was concluded in 1981 with the publication of this report.

The area described in this report has been tentatively determined to be a potential Federal coal development area. The purpose of this report is to provide information on the area's reclamation potential should coal development occur. This report will assist managers in making final Federal coal leasing decisions.

Limited copies of this report are available from:

Bureau of Land Management
New Mexico State Office
U.S. Post Office and Federal Bldg.
P.O. Box 1449
Sante Fe, NM 87501
505-988-6511

Please reference the title and report number 17-77 when making a request for this report.

Other reports available through Technical Investigations in Support of the Federal Coal Management Program are:

Report Name	Number	Report Name	Number
Otter Creek, MT	1-75	Garrison, ND	37-80
Hanna Basin, WY	2-75		
Taylor Creek, CO	3-75	Characterization of Major	
Alton, UT	4-75	Soils Found in Proposed Oil	
Bisti, NM	5-76	Shale and Coal Development	
Foidel Creek, CO	6-76	Areas of Northwest Colorado	23-76
Red Rim, WY	7-76		
Bear Creek, MT	8-76	Hydrologic Consideration in	
Horse Nose Butte, ND	9-76	Coal Activity Planning	33-80
Beulah Trench, ND	10-77		
Hanging Woman, MT	12-77	Chromo 4, MT	46-75
White Tail Butte, WY	13-77	Otter Creek East, MT	47-77
Henry Mountain, UT	15-77	Dam Creek, MT	48-77
Emery, UT	16-77	Shy/6, MT	49-78
		Newell/28, MT	50-78

For more information on these reports, contact:

Bureau of Land Management
Reclamation Data Group
DFC, Bldg. 50, D-450
Denver, CO 80225
303-234-2374

50272-101

REPORT DOCUMENTATION PAGE	1. REPORT NO	2.	3. Recipient's Accession No.
	BLM-YA-PT-81-009-7330		

4. Title and Subtitle

Kimbeto Study Area Report: Resource and Potential Reclamation Evaluation Final

5. Report Date
September 1981

6.

7. Author(s)
Bureau of Reclamation, Dick Griese (ED)

8. Performing Organization Rept. No.
17-77

9. Performing Organization Name and Address

Bureau of Reclamation
Commerce Bldg., Suite 201
714 S. Tyler
Amarillo, TX 79101

10. Project/Task/Work Unit No.

11. Contract(C) or Grant(G) No.
(C)
(G)

12. Sponsoring Organization Name and Address

BLM, New Mexico State Office
U.S. Post Office and Federal Bldg.
P.O. Box 1449
Santa Fe, NM 87501

13. Type of Report & Period Covered
Final 1977-1981

14.

15. Supplementary Notes
Prepared jointly by Bureau of Land Management, Bureau of Reclamation and Geological Survey.

16. Abstract (Limit: 200 words)

Report provides information on reclamation potential (and on coal resources) of study area (SA) should coal development occur. SA is located in San Juan County, New Mexico. Restoration of existing levels of vegetation is recommended. Irrigation required for 2 years. Thirty-five percent of surface of SA has suitable planting media. Much of SA is badlands. Many soils are saline or sodic. Bedrock generally not suitable planting media in present state. Revegetation will be difficult because of semiarid climate. Subbituminous coal beds average 5.4 feet in thickness; 68 percent of coal is overlain by 200 feet or less of overburden. Measured and indicated coal with less than 400 feet of overburden are 69.1 million and 369.1 million short tons. Average Btu value, ash content, and sulfur content is 8,250, 23.4 percent, and 0.5 percent. Considering geochemical factors, bedrock should not adversely affect ground water element concentrations. SA has low vegetative productivity. Several species, especially galleta and alkali sacaton, would be effective in revegetation of the SA. Hydrology or water quality considerations should not cause problems with mining or reclamation. Surface and ground water supplies suitable for irrigation may be available.

17. Document Analysis a. Descriptors

0510 Environmental Surveys
0807 Coal Deposits
1407 Reclamation

Bureau of Land Management
Library
Bldg. 50, Denver Federal Center
Denver, CO 80225

b. Identifiers/Open-Ended Terms

Mined-land reclamation, New Mexico

c. COSATI Field/Group

18. Availability Statement	19. Security Class (This Report)	21. No. of Pages
Release unlimited, BLM, New Mexico State Office, U.S. Post Office and Federal Bldg., P.O. Box 1449, Santa Fe, NM 87501	unclassified	
	20. Security Class (This Page) unclassified	22. Price

(See ANSI-Z39.18)

See Instructions on Reverse

OPTIONAL FORM 272 (4-77)
(Formerly NTIS-35)
Department of Commerce

ACKNOWLEDGEMENTS

As compilers of and contributors to this report, the Bureau of Reclamation, Southwest Region, gratefully acknowledges the individuals and agencies who helped prepare this report, especially:

Colorado State University, Department of Agronomy

Dr. Robert D. Heil

U.S. Geological Survey
Water Resources Division
New Mexico District Office

Bob Hejl
Kim Ong
Jack Dewey

Central Region Research Project

Farrel A. Branson
Reuben F. Miller
Martha H. Mustard
Lynn M. Shown

Bureau of Land Management
Library
Bldg. 50, Denver Federal Center
Denver, CO 80225

Geologic Division
Branch of Coal Resources

Gary B. Schneider

Todd Hinkley

Bureau of Land Management

Byron Shark, Denver Federal Center
Malcolm Charlton, New Mexico State Office
Monte McClendon and Tim Kreager, Farmington Resource Area Office

Bureau of Reclamation

Gregory W. Brockman and Bill Morrison, Engineering and Research Center
Tony Cappellucci, Lower Missouri Region

The following individuals from the Bureau of Reclamation, Southwest Region, helped prepare the report:

Dick Griese
Joe L. Jackson
Roland Gene Moore
Willard L. Witt, Jr.

#11552366
ID880/8702

TD
195
.S75
E47
NO.17
C.2

RESOURCE AND POTENTIAL RECLAMATION EVALUATION

KIMBETO STUDY AREA

BLM LIBRARY
SC-324A, BLDG. 50
DENVER FEDERAL CENTER
P. O. BOX 25047
DENVER, CO 80225-0047

REPORT NO. 17-77

U.S. Department of the Interior
Bureau of Land Management--Bureau of Reclamation--U.S. Geological Survey

September 1981

BLM LIBRARY
SC-324A, BLDG. 50
DENVER FEDERAL CENTER
P. O. BOX 25047
DENVER, CO 80225-0047

In May of 1981, the Secretary of the Interior approved changing the Water and Power Resources Service back to its former name, the Bureau of Reclamation. All references in this publication to the Water and Power Resources Service should be considered synonymous with the Bureau of Reclamation.

RESOURCE AND POTENTIAL RECLAMATION EVALUATION
KIMBETO STUDY AREA

TABLE OF CONTENTS

Section		Page
A.	INTRODUCTION	A-1
	Objectives	A-1
	Authority	A-1
	Responsibilities	A-2
	Bureau of Land Management	A-2
	Bureau of Reclamation (BR)	A-2
	Geological Survey (GS)	A-3
	Kimbeto Study	A-3
	Location and Setting	A-3
B.	CLIMATE	B-1
	Temperature	B-1
	Precipitation	B-1
	Other climatic characteristics	B-2
	Effect of weather on site revegetation	B-3
	Climate and aspect (exposure)	B-3
	Evapotranspiration demand	B-3
C.	PHYSIOGRAPHY, RELIEF, AND DRAINAGE; GEOLOGY	C-1
	Physiography, Relief, and Drainage	C-1
	Geology	C-2
	Regional Geology	C-2
	Study area geology	C-3
	Investigations	C-3
	Geology	C-4
	Aquifers	C-6
	Engineering geology	C-6
D.	COAL RESOURCES	D-1
	Estimation and classification of coal resources	D-1
	Tabulation of estimated coal resources	D-1
	Measured	D-1
	Indicated	D-7
	Inferred	D-7
	Characteristics used in resource evaluation	D-7
	Weight	D-7
	Thickness of beds	D-7
	Thickness of overburden	D-8
	Summary of Resources	D-8
	Chemical analyses of coal and coaly shale in the Fruitland Formation Kimbeto study site	D-8
	Discussion	D-8
E.	OVERBURDEN GEOCHEMISTRY	E-1
	Sampling Scheme	E-1
	Classification of Samples into Rock Types	E-2

RESOURCE AND POTENTIAL RECLAMATION EVALUATION
KIMBETO STUDY AREA

TABLE OF CONTENTS (con.)

Section		Page
E.	OVERBURDEN GEOCHEMISTRY (con.)	
	Analytical	E-2
	Chemical Distinctiveness of Rock Types	E-2
	Chemistry of Kimbeto (and Ojo Encino) Rocks Compared to Other Overburden Rocks of the Same and Different Ages	E-3
	Similarity of Kimbeto Overburden Rocks to Natural San Juan Basin Soils	E-5
	Relative Abundance of Rock Types	E-5
F.	LAND AND OVERBURDEN	F-1
	Major Land Categories	F-1
	Mesas	F-1
	Valleys	F-1
	Sandy	F-3
	Saline-sodic	F-4
	Badlands	F-5
	Miscellaneous	F-5
	Active dunes	F-5
	Hummocky areas	F-6
	Stream channels	F-6
	Land Suitability	F-7
	Procedures	F-7
	Summary of land classification results	F-8
	Bedrock Suitability	F-10
	Toxic Materials	F-11
	Additional Studies Before Mining	F-11
	Quality of Irrigation Water Supplies	F-12
G.	VEGETATION	G-1
H.	SOIL-MOISTURE RELATIONSHIPS ASSOCIATED WITH VEGETATION TYPES AND LANDFORMS	H-1
	Dunes	H-1
	Flood plains	H-3
	Mesas	H-5
	Slopes	H-5
	Badlands and Blowout	H-7
	Summary and Conclusions	H-7
I.	SEDIMENT YIELDS	I-1
	Source-Area Sediment Yields	I-2
	Sediment Discharge from Drainage Basins	I-4
	Effects of Mining	I-4
J.	HYDROLOGY AND WATER SUPPLY	J-1
	Surface Water	J-1
	Quantity	J-1
	Chemical Quality	J-2
	Suspended Sediment	J-4

RESOURCE AND POTENTIAL RECLAMATION EVALUATION
KIMBETO STUDY AREA

TABLE OF CONTENTS (con.)

Section		Page
J.	HYDROLOGY AND WATER SUPPLY (con.)	
	Ground Water	J-5
	Overburden	J-5
	Coal seam	J-5
	Pictured Cliffs Sandstone	J-5
	Channel alluvium	J-5
	Deep aquifers	J-6
	Water Supply	J-6
	Suitable Supplies for Reclamation	J-6
	Availability for Mining Operation	J-7
K.	PRESENT LAND USE, POST-MINING LAND USE, AND LEGAL REQUIREMENTS PERTAINING TO MINED-LAND RECLAMATION	K-1
	Present Land Use	K-1
	Post-Mining Land Use	K-1
	Legal Requirements Pertaining to Mined-Land Reclamation	K-2
	Federal regulations	K-2
	State regulations	K-2
L.	CONCLUSIONS ON STUDY AREA RECLAMATION POTENTIAL	L-1
	Alternatives	L-1
	No mining	L-1
	Natural recovery	L-1
	Total revegetation	L-1
	Restoration of existing levels of vegetation	L-2
	Land and Overburden Conclusions (Reclamation by Restoring Existing Levels of Vegetation)	L-3
	Actions during the premining and mining periods	L-3
	Selection of planting media	L-3
	Handling and placement of soil and bedrock material	L-3
	Stockpiling of soil or bedrock to be used on surface	L-3
	Probable resulting soil profile	L-4
	Placement and isolation of toxic materials	L-4
	Grading	L-4
	Actions during the post-mining period	L-5
	Evaluation of surface material for revegetation	L-5
	Selection of plant species	L-6
	Native species (first priority)	L-6
	Adapted introduced species (second priority)	L-6
	Nutrient deficiencies-additives	L-6
	Irrigation	L-7
	Seeding methods	L-8
	Drill seeding	L-8
	Hydroseeding	L-9
	Mechanical broadcasting	L-9
	Hand broadcasting	L-9

RESOURCE AND POTENTIAL RECLAMATION EVALUATION
KIMBETO STUDY AREA

TABLE OF CONTENTS (con.)

Section		Page
L.	CONCLUSIONS ON STUDY AREA RECLAMATION POTENTIAL (con.)	
	Seeding Methods (con.)	
	Additional planting procedures	L-9
	Fertilizer application	L-9
	Surface soil protection	L-10
	Management	L-11
	Overburden Geochemistry Conclusions	L-11
	Summary of area characteristics in relation to reclamation potential	L-11
	Reclamation potential of the area based on anticipated post-mining use as designated by BLM (livestock production and wildlife habitat)	L-11
	Major reclamation problems and measures necessary to establish conditions suitable for anticipated post-mining use	L-11
	Vegetation Conclusions	L-12
	Important study area characteristics in relation to reclamation potential	L-12
	Reclamation potential of the study area based on anticipated post-mining land use (livestock production and wildlife habitat)	L-12
	Major reclamation problem	L-12
	Soil-Moisture Relationships Conclusions	L-12
	Important study area characteristics in relation to reclamation potential	L-12
	Reclamation potential of the study area based on anticipated post-mining uses	L-13
	Major reclamation problem	L-13
	Measures necessary to establish conditions suitable for post-mining uses of livestock production and wildlife habitat	L-13
	Sediment Yield Conclusions	L-13
	Important study area characteristics that influence the reclamation potential	L-13
	Reclamation potential of the study area based on the planned post-mining land uses	L-14
	Major reclamation problem	L-14
	Measures necessary to establish condition for post-mining land uses--livestock production and wildlife habitat	L-14
	Hydrology and Water Supply Conclusions	L-14
	Effects of surface mining and subsequent reclamation on hydrology	L-14
	Probable impacts on hydrologic budget	L-14
	Potential changes in sediment yield	L-16
	Compliance with water-quality regulations	L-17
	Water supply	L-18

RESOURCE AND POTENTIAL RECLAMATION EVALUATION
KIMBETO STUDY AREA

TABLE OF CONTENTS (con.)

Section		Page
M.	REFERENCES	M-1
	Climate	M-1
	Coal Resources	M-2
	Hydrology and Water Supply	M-4
	Land and Overburden Material	M-5
	Overburden Geochemistry	M-6
	Physiography, Relief, and Drainage; Geology	M-7
	Sediment Yields	M-8
	Soil-Moisture Relationships Associated with Vegetation Types and Landforms	M-9
N.	GEOLOGY APPENDIX follows	M-9
	Geologic Logs. follows	M-9
O.	COAL RESOURCES APPENDIX.	O-1
	Origin of Coal	O-1
	Classification of Coal	O-1
	Rank of Coal	O-2
	Type of Coal	O-4
	Grade of Coal	O-4
	Chemical Analyses of Coal and Coaly Shale in the Fruitland Formation Kimbeto Study Site	O-7
	Explanation of statistical terms used in summary tables	O-7
P.	OVERBURDEN GEOCHEMISTRY APPENDIX	P-1
	Complete Tabulation of Bulk Chemical Data for Kimbeto Overburden Rock Drill Core Samples	P-1
Q.	LAND AND OVERBURDEN APPENDIX follows	P-13
	Major Land Categories	Q-1
	Land Classifications	Q-3
	Taxonomic Classification of Soils.	Q-5
	Soil Inventory	Q-5
	SMU 7001 - R22 - Duneland, 227 acres - 1.87 percent of study area.	Q-8
	SMU 7002 - R3 - Badlands, 5,374 acres - 44.19 percent of study area	Q-8
	SMU 7004 - 19E - Doak-Shiprock-Sheppard-Mayqueen Association - 1,810 acres - 14.88 percent of study area	Q-9
	SMU 7005 - R13 - Riverwash (Fluvents) frequently flooded (0 to 1 percent slope) 354 acres, 2.91 percent of study area.	Q-10
	SMU 7010 - 40M - Stumble-Turley-Notal Association, 1,600 acres, 13.16 percent of study area	Q-10
	SMU 7012 - 19D - Doak-Nageesi Association, gently sloping, 1,184 acres, 9.74 percent of study area	Q-11

RESOURCE AND POTENTIAL RECLAMATION EVALUATION
KIMBETO STUDY AREA

TABLE OF CONTENTS (con.)

Section		Page
Q.	LAND AND OVERBURDEN APPENDIX (con.)	
	Soil Inventory (con.)	
	SMU 7013 - 16C - Blancot-Notal Association, gently sloping, 664 acres, 5.46 percent of study area	Q-12
	SMU 7014 - 09H - Huerfano-Muff-Uffens Complex, gently sloping, 704 acres, 5.79 percent of study area	Q-13
	SMU 7015 - R14 - Fruitland-Persayo-Sheppard Complex, hilly, 243 acres - 2.00 percent of study area	Q-14
	Results of Weathering Tests Conducted on Core Samples from Kimbeto, New Mexico	Q-15
	Test procedures	Q-15
	Test results	Q-15
	Characterization of Strata Overlying Coal Seams as Plant Growth Media	Q-20
	Acknowledgments	Q-21
	Introduction	Q-22
	Procedures	Q-23
	Greenhouse	Q-23
	Soil preparation	Q-23
	Field capacity	Q-23
	Fertilizer treatment	Q-23
	Planting	Q-24
	Daily management	Q-24
	Harvest	Q-24
	Soil and Overburden Analysis	Q-24
	Electrical conductivity	Q-24
	Iron, zinc, copper and manganese	Q-24
	pH	Q-25
	SAR	Q-25
	Extractable Phosphorus	Q-25
	Plant Tissue Analyses	Q-25
	Criteria for Interpretation	Q-26
	Soil Diagnostic Criteria	Q-26
	Plant Diagnostic Criteria	Q-27
	Statistical Analysis	Q-28
	Results and Discussion	Q-29
	Introduction	Q-29
	Kimbeto Study Area	Q-29
	Studies performed	Q-29
	Summary of results	Q-29
	General Conclusions	Q-48

RESOURCE AND POTENTIAL RECLAMATION EVALUATION
KIMBETO STUDY AREA

TABLE OF CONTENTS (con.)

Section		Page
	Screenable Testing Laboratory Results	Q-50
	Description of and references for laboratory procedures	Q-51
	Detailed Soil-Inventory Tables	Q-65
R.	SOIL-MOISTURE RELATIONSHIPS ASSOCIATED WITH VEGETATION TYPES AND LANDFORMS APPENDIX	R-1
	Concepts and Methods for Soil Moisture Relationships Associated with Vegetation Types and Landforms	R-1
	Concepts	R-1
	Methods	R-3
S.	HYDROLOGY AND WATER SUPPLY APPENDIX	follows R-14
T.	SELECTED GOVERNMENTAL COAL MINING REGULATIONS APPENDIX	T-1
	Federal Regulations	T-1
	Title 43--Public Lands, Interior	
	Section 3041.0-1 - Purpose	T-1
	Section 3041.1-2 - Preliminary Data	T-1
	Section 3041.2-2 - Obligations and Standards of Performance	T-2
	Section 3041.5 - Completion of Operations and Abandonment	T-4
	Title 30--Mineral Resources	T-5
	Section 211.75 - Applicability of State Law	T-5
	Section 700.1 - Scope	T-6
	State Regulations	T-8
	Section 1 - Permit Application - Fees	T-8
	Section 2 - Mining Plan	T-8
	Section 5 - Grading	T-8
	Section 6 - Revegetation	T-9

TABLES

No.		Page
B-1	Study Area Freeze Data - Chaco Canyon (Elevation 6175)	B-2
D-1	USGS sample number, hole number, location and depth inverval for 17 coal and shale samples from the Kimbeto study site, San Juan County, N. Mex.	D-2
D-2	Proximate and ultimate analyses, heat-of-combustion, forms-of-sulfur, free-swelling, index, and ash-fusion temperature determination for 17 coal and shale samples from the Fruitland Formation, Kimbeto study site, San Juan County, N. Mex.	D-3
D-3	Summary of estimated identified coal resources of the Kimbeto EMRIA Study Site	D-6
F-1	Land Suitability Specifications for Lands to Be Used as a Source of Topsoil for Reclamation of Surface-Mined Areas	F-2

RESOURCE AND POTENTIAL RECLAMATION EVALUATION
KIMBETO STUDY AREA

TABLE OF CONTENTS (con.)

TABLES

No.		Page
F-2	Land Class and Major Subclass Characteristics	F-9
G-1	Percentage Ground Cover and Annual Yield of Vegetation at Representative Sites in September 1976	G-3
H-1	Vegetation cover, in percent, at dunes sites	H-2
H-2	Vegetation cover, in percent, at flood plains sites	H-4
H-3	Vegetation cover, in percent, at mesa sites	H-6
H-4	Vegetation cover, in percent, on slope sites	H-8
H-5	Vegetation cover, in percent, on badland and blowout sites	H-9
H-6	Conversion Factors	H-11
I-1	Sediment accumulations in stock ponds	I-2
I-2	Analyses of channel classification for drainage basins	I-2
I-3	Estimated annual sediment discharge from drainage basins	I-4
J-1	Flood-frequency discharge estimates for major streams in the Kimbeto EMRIA study area	J-2
L-1	Compliance of Natural Surface Waters in the Kimbeto Study Area to Water Quality Regulations	L-19
L-2	Compliance of Natural Ground Waters in the Kimbeto Study Area to Water Quality Regulations	L-20
O-1	Classification of coals by rank	O-3
O-2	Estimated identified coal resources of the Fruitland Coal, Kimbeto EMRIA site, San Juan County, New Mexico	O-5
O-3	Major and minor oxide and trace element composition of the laboratory ash of 17 coal and shale samples from the Fruitland Formation, Kimbeto Study, San Juan County, N. Mex.	O-8
O-4	Content of nine trace elements of 17 coal and shale samples from the Fruitland Formation, Kimbeto Study, San Juan County, N. Mex	O-10
O-5	Major, minor, and trace element composition of 17 coal and shale samples from the Fruitland Formation, Kimbeto Study, San Juan County, N. Mex	O-11
O-6	Elements looked for but not detected in coal and shale samples from the Fruitland Formation, Kimbeto study site, San Juan County, N. Mex	O-13
O-7	Arithmetic mean, observed range, geometric mean, and geometric deviation of proximate and ultimate analyses, heat of combustion, forms of sulfur, and ash-fusion temperatures, of 14 coal samples from the Fruitland Formation, Kimbeto study site, San Juan County, N. Mex	O-14

RESOURCE AND POTENTIAL RECLAMATION EVALUATION
KIMBETO STUDY AREA

TABLE OF CONTENTS (con.)

TABLES

No.		Page
O-8	Arithmetic mean, observed range, geometric mean, and geometric deviation of ash content and contents of 10 major and minor oxides in the laboratory ash of 14 coal samples from the Fruitland Formation, Kimbeto study site, San Juan County, N. Mex	O-15
O-9	Arithmetic mean, observed range, geometric mean, and geometric deviation of 35 elements in 14 coal samples from the Fruitland Formation at the Kimbeto study site, San Juan County, N. Mex.	O-16
P-1	Complete tabulation of bulk chemical data, Kimbeto overburden rock, dry weight basis.	P-2
P-2	Bulk chemical composition of overburden rocks at Kimbeto and other sites where coal is overlain by Cretaceous age rocks; also soils and mine spoil material from the San Juan Basin	P-12
P-3	Dispersion of data on bulk chemical composition of overburden rocks at Kimbeto and other sites where coal is overlain by Cretaceous age rocks; also soils and mine spoil material from the San Juan Basin	P-13
Q-1	Acreages of Major Land Categories.	Q-2
Q-2	Land Classification Results	Q-4
Q-3	Taxonomy of Soil Series at the Kimbeto Study Site.	Q-6
Q-4	Soil Association Mapping Units Acreages.	Q-7
Q-5	Weathering Tests	Q-17
Q-6	Greenhouse and Laboratory Data	Q-32
Q-7	Kimbeto Site Materials Classed as Unsuitable due to Salinity and SAR.	Q-45
Q-8	Kimbeto Site Materials Classed as being Unsuitable due to SAR.	Q-46
Q-9	Suitability ratings for Kimbeto site Materials not shown in Tables Q-7 and Q-8	Q-47
Q-10	Results of Laboratory Tests on Auger Hole/Drill Hole Samples	Q-53
Q-11	Mechanical Analysis of Soil Samples.	Q-60
Q-12	Soil Survey Interpretations.	Q-66
Q-13	Point Site Land Characterization	Q-90
Q-14	Determination of Erosion Condition Class	Q-96
Q-15	Vegetation-Soil Description.	Q-103
R-1	Data for defining moisture relations in soils.	R-4
R-2	Conversion Factors	R-12
S-1	Summary of runoff volumes at and near the Kimbeto EMRIA study area.	S-1

RESOURCE AND POTENTIAL RECLAMATION EVALUATION
KIMBETO STUDY AREA

TABLE OF CONTENTS (con.)

TABLES

No.		Page
S-2	Summary of average monthly suspended-sediment discharge loads for Ah-shi-sle-pah, De-na-zin and Hunter Washes	S-2
S-3	Selected or average values of major chemical and physical parameters of surface waters in or near the Kimbeto EMRIA study area	S-3
S-4	Selected or average values of trace element parameters for surface waters in or near the Kimbeto EMRIA study area.	S-4
S-5	Values of major chemical and physical parameters in ground waters within or near the Kimbeto study area	S-5
S-6	Values of trace element parameters in ground waters within or near the Kimbeto study area	S-6
S-7	Values of major chemical and physical parameters in ground waters within or near the Kimbeto study area	S-7
S-8	Values of trace element parameters in ground waters within or near the Kimbeto study area	S-8
S-9	Summary of pertinent provisions of water-quality regulations with respect to mining at the Kimbeto study area	S-9

FIGURES

No.			Page
A-1	Kimbeto Study Area Location Map	follows	A-3
C-1	Topography	follows	C-2
C-2	Structural Elements of San Juan Basin	follows	C-2
C-3	Regional Geology	follows	C-2
C-4	Study Area Geologic Map	follows	C-4
C-5	Digrammatic Geological Sections	follows	C-6
C-6	Digrammatic Geological Sections	follows	C-6
C-7	Overburden Thickness Map	follows	C-6
F-1	Major Land Categories	follows	F-2
F-2	Land Classification Symbols	follows	F-9
F-3	General Land Classification	follows	F-9
F-4	Detailed Land Classification	follows	F-9
G-1	Vegetation Map of Kimbeto Wash Study Area, New Mexico - 1976	follows	G-3
H-1	Locations of sampling sites for defining moisture relations in soils of the Kimbeto Wash EMRIA study area, New Mexico--1976.	follows	H-1
H-2	Moisture relations in soils of dune sites	follows	H-1
H-3	Moisture relations in soils for sites on stabilized upland dunes	follows	H-1

RESOURCE AND POTENTIAL RECLAMATION EVALUATION
KIMBETO STUDY AREA

TABLE OF CONTENTS (con.)

FIGURES

No.			Page
H-4	Moisture relations in soils for greasewood-alkali sacaton sites on flood plains	follows	H-4
H-5	Moisture relations in soils for alkali sacaton sites on flood plains	follows	H-5
H-6	Moisture relations in soils for sites on mesas . .	follows	H-5
H-7	Moisture relations in soils on slopes	follows	H-8
H-8	Moisture relations in soils for a badland site on a bentonite bed, and for a nearby site with a fine-textured soil in a blowout	follows	H-9
I-1	Source Area Sediment Yields for the Kimbeto Wash EMRIA Study Area, New Mexico - 1976	follows	I-2
I-2	Channel Classification and Drainage Basins of the Kimbeto Wash Study Area, New Mexico - 1976	follows	I-2
O-1	Comparison on Moist, Mineral-Matter-Free Basis of Heat Values and Proximate Analyses of Coal of Different Ranks	follows	O-2
Q-1 through Q-24	Major Land Categories	follow	Q-2
Q-25 through Q-35	Profile Descriptions and Land Classification . . .	follow	Q-4
Q-36 through Q-37	Soil Mapping Units	follow	Q-8
Q-38	Results of weathering tests for sandstone samples K-1 and K-2	follows	Q-19
Q-39	Results of weathering tests for sandy siltstone samples K-3 and sandstone sample K-4	follows	Q-19
Q-40	Results of weathering tests for shale samples K-5 and K-6	follows	Q-19
Q-41	Results of weathering tests for sandstone sample K-7 and siltstone sample K-8	follows	Q-19
Q-42	Results of weathering tests for silty shale sample K-9 and sandstone sample K-10	follows	Q-19
Q-43	Results of one-year outdoor weathering for Specimens K-1B, K-2B, K-3B, and K-4B	follows	Q-19
Q-44	Results of one-year outdoor weathering for Specimens K-5B, K-6B, K-7B, and K-8B	follows	Q-19
Q-45	Results of one-year outdoor weathering for Specimens K-9B and K-10B	follows	Q-19

RESOURCE AND POTENTIAL RECLAMATION EVALUATION
KIMBETO STUDY AREA

TABLE OF CONTENTS (con.)

FIGURES

No.		Page
R-1	A graphic model showing the relationship of moisture-retention force to moisture content for a particular soil . . . . . follows	R-1
R-2	Relationship used to determine void-moisture capacity (VMC) of soils from volume weight (VW) . follows	R-2
S-1	Hydrologic data collection sites in the Kimbeto EMRIA coal study area, northwestern New Mexico . . follows	S-12
S-2	Relationship between daily suspended-sediment discharge and water discharge, Ah-shi-sle-pah Wash at Kimbeto EMRIA study area, 1977-78 . . . . follows	S-12
S-3	Modeled potentiometric surface for the Morrison Formation . . . . . follows	S-12
S-4	Modeled drawdown, in feet, after pumping for 10 years at a rate of 400 gallons per minute, in the Morrison Formation at the Kimbeto EMRIA study area . . . . . follows	S-12
S-5	Modeled drawdown, in feet, after pumping for 20 years at a rate of 400 gallons per minute, in the Morrison Formation at the Kimbeto EMRIA study area . . . . . follows	S-12
S-6	Modeled drawdown, in feet, after pumping for 40 years at a rate of 400 gallons per minute, in the Morrison Formation at the Kimbeto EMRIA study area . . . . . follows	S-12

PHOTOS

No.		Page
C-1	Looking southeast from DH-1K toward a terrace ridge in the background. (See figure C-7 for locations of DH's.) . follows	C-2
C-2	Looking north from DH-3K at a partially stabilized sand dune in the foreground and badlands (Kirtland Formation) in the background . . . . . follows	C-2
C-3	Looking northeast from DH-4K along a crest of a terrace ridge. A Navajo home is in the background . . . . . follows	C-4
C-4	Looking west at DH-5K, in the badlands (Kirtland Formation) . . . . . follows	C-4

RESOURCE AND POTENTIAL RECLAMATION EVALUATION
KIMBETO STUDY AREA

TABLE OF CONTENTS (con.)

PHOTOS

No.		Page
C-5	Looking north from DH-8K toward a terrace ridge (extreme background) overlying the Kirtland Formation . . . . . follows	C-6
C-6	Looking north from DH-9K at a stabilized sand dune (background) near Betonnie Tsosie Wash . . . . . follows	C-6
C-7	Looking south from DH-10K, located on a terrace ridge (foreground), toward the badlands (background) . . . . . follows	C-6
F-1	Looking south near profile 80 at Class 1 mesa land. (See figure F-1 for profile locations.) . . . . . follows	F-2
F-2	Edge view of mesa land (background) near profile 6, with badlands in foreground . . . . . follows	F-2
F-3	Looking east near profile 4 at Class 2 land in foreground, badlands in middleground, and mesa in background . . . follows	F-4
F-4	Ah-Shi-Sle-Pah Wash west of profile 62, flanked by shaley coal cut-bank, with sandy land in background . . . . . follows	F-4
F-5	Looking south near profile 62, at bare weathered shale and sandstone in foreground and badlands in background . . . . follows	F-6
F-6	Sandstone capped pedestals in badlands south of profile 63 . . . . . follows	F-6
F-7	Looking west near profile 8 at Class 2 land, with some badlands on left and right . . . . . follows	F-11
F-8	Looking north, southwest of profile 62, at erosion and bare weathered shale and sandstone with some coal in foreground and small slightly vegetated sandy ridges and mesa in background . . . . . follows	F-11

SECTION A

INTRODUCTION

SECTION A

INTRODUCTION

A growing and affluent society is creating an ever increasing need for energy. Attention has focused on the energy fuel sources of the Western States, primarily the Rocky Mountains and the Northern Great Plains Coal Provinces, due to the abundance, ease of extraction, and quality of the resources in these areas. It is the responsibility of the Bureau of Land Management (BLM) to assist in meeting these energy demands and, at the same time, provide sound reclamation and rehabilitation guidelines so that disturbed lands are returned to a useful state.

Objectives

The principal objective of this report is to assure adequate baseline physical and chemical data for choosing reclamation goals and for establishing lease stipulations for energy mineral exploration, mining, and reclamation. */

Other objectives include:

A. Provide data to minimize environmental impacts from surface mining of energy minerals on public lands administered by the BLM.

B. Provide environmental resource information needed to implement effective reclamation programs.

C. Provide resource and impact information for:

1. Preparation of Environmental Analysis Reports (EAR) and Environmental Impact Statements (EIS).

2. Use during site selection within the Secretary's energy leasing programs.

3. Support of State and local regional development and land use planning efforts.

Authority

Public Land Administration Act of July 14, 1960 (74 Stat. 506).

---

*/ The abbreviation EMRIA (Energy Mineral Rehabilitation Inventory and Analysis) is used often in this report. EMRIA is the old name of the program under which this report was prepared. Preparation of the report was too advanced to delete the term.

Responsibilities */

Bureau of Land Management

A. Selects reclamation study areas for coordinated investigation of vegetation, soil, geological structure, surface water, and ground water.

B. Acts as contracting officer in the coordination, establishment, and execution of work orders (contracts).

C. Reviews and consolidates work order and field office data and prepares information for reports published by the Bureau of Reclamation.

D. Distributes technical data, reports, and reclamation and rehabilitation recommendations to BLM field offices.

Bureau of Reclamation (BR)

A. Evaluates land and overburden **/ as a source of suitable planting media in a revegetation program.

B. Prepares soil inventories.

C. Recommends to BLM district office suitable plant species for areas to be revegetated.

D. Obtains core samples of bedrock overburden, coal, and bedrock immediately below coal.

E. Installs casing in holes selected for ground water observation wells.

F. Prepares a written and graphic description of pertinent geologic aspects of the study area.

G. Advises BLM district office on reclamation techniques.

H. Publishes Resource and Potential Reclamation Evaluation.

---

*/ Because different authors prepared different parts of this report, conclusions in one part of the report may not completely agree with those in another part.

**/ Overburden is the material, both consolidated (bedrock) and unconsolidated (surficial materials, such as soil, usually overlying the bedrock), overlying the coal.

Geological Survey (GS)

A. Conducts studies of vegetative types and of moisture relationships in associated soils. Studies will result in vegetation maps and related soil characteristics.

B. Prepares sediment yield maps.

C. Assesses reclamation potential based on available water, on effects of surface mining on area hydrology, and on measures required to prevent adverse effects on area hydrology.

D. Estimates annual runoff and peak flows.

E. Collects and interprets data to predict alternative solutions to ground water problems encountered during mining and reclamation.

F. Implements monitoring system to define baseline conditions and to document ground water flow and quality changes caused by mining and reclamation.

G. Prepares potentiometric maps.

H. Prepares geophysical well logs.

I. Estimates coal resources.

J. Performs laboratory tests on coal resources.

K. Presents results of laboratory tests on coal resources.

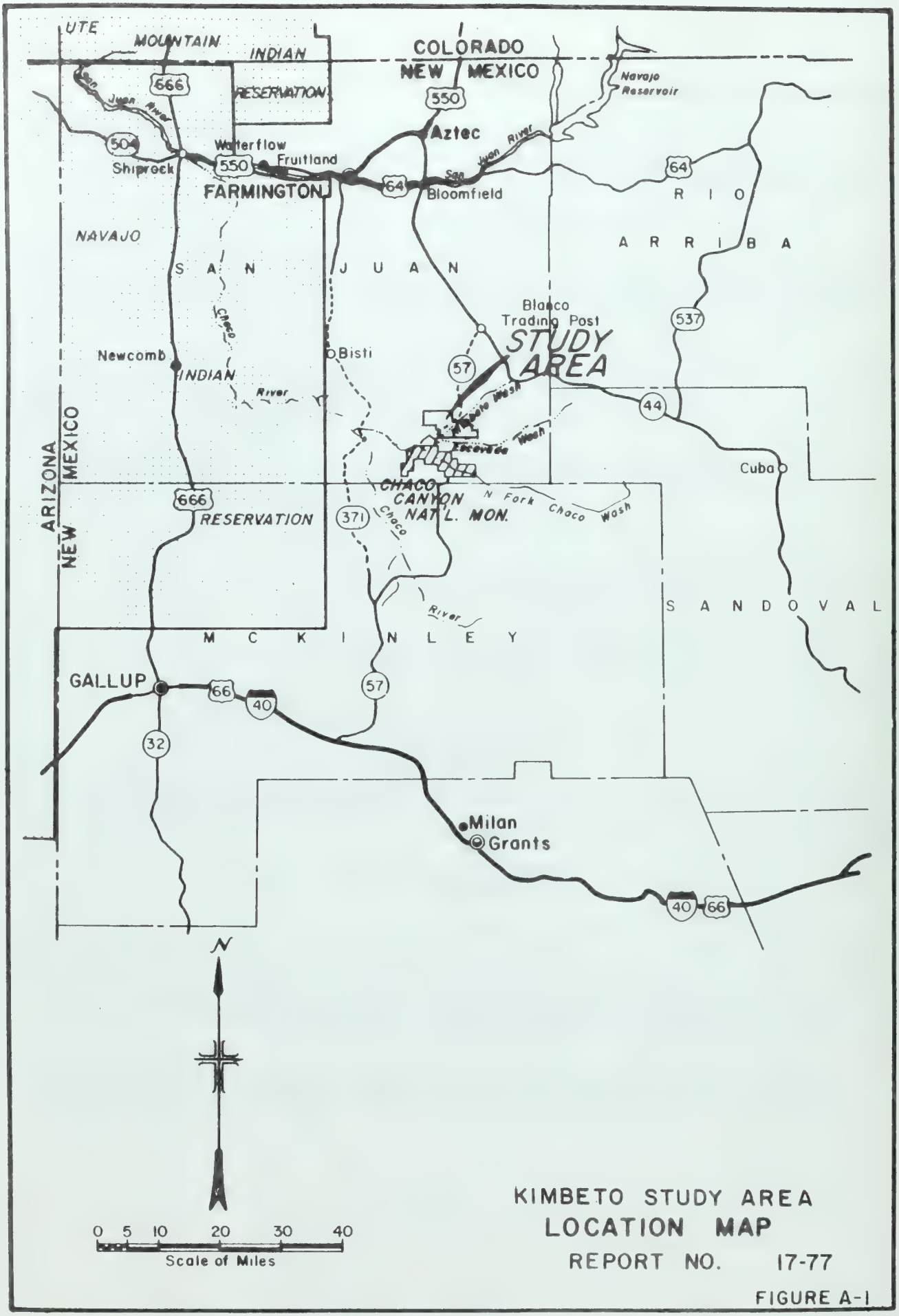
Kimbeto Study

Fieldwork for the study was conducted from September 1976 to September 1977. Laboratory work and office evaluations were conducted from September 1977 to December 1980.

Location and Setting

The location of the 12,160-acre Kimbeto study area is shown on the cover of the report and on figure A-1. The eastern half of San Juan County is mostly public domain, and the study area is located near the south boundary of this large tract of public domain. All of the surface of the study area is federally owned, and almost all of the minerals are federally owned.*

* Minerals for Section 16, T. 22 N., R. 10 W., are owned by the State of New Mexico and for the NE1/4 sec. 27 (same T. and R.) by a private entity.



KIMBETO STUDY AREA
LOCATION MAP
REPORT NO. 17-77

FIGURE A-1

Lands included in the study area* are tabulated as follows:

T. 22 N., R. 11 W.
sec. 12

T. 22 N., R. 10 W.
sec. 4, 5; S1/2 sec. 6; secs. 7, 8, 9; SW1/4 sec. 10; SW1/4 sec. 11; SW1/4 sec. 10; SW1/4 sec. 11; SW1/4 sec. 13; secs. 14, 15, 16, 17, 18; N1/2 sec. 19; secs. 22, 23, 24, 25; N1/2 sec. 26; NE1/4 sec. 27.

T. 22 N., R. 9 W.
S1/2 sec, 19; sec. 30

(Refer to figure C-1 for the location of these lands and the study area boundary.)

The study area is located in a semiarid desert-like region with low rainfall (average annual precipitation is 8.8 inches), cool temperatures (average annual temperature is 49°), and frequent winds.

The study area is an area of sharp contrasts, including badlands, boldly scarped pinnacles and mesas, sand dunes, sand choked dry washes, and terrace ridges. However, much of the study area (50 percent) is composed of mesas and valleys with level to gently sloping, or gently rolling, surfaces. Much of the study area (41 percent) is composed of badlands. A small amount of the area (9 percent) is composed of active dunes, hummocky areas, and stream channels. Three washes pass through the study area. The elevation of the study area averages about 6,300 feet above sea level.

Vegetation is sparse and consists of the northern desert shrub type, characterized by sagebrush, bunch grass, and their associates. In some places, vegetation gives way to bare soil, bare rock badlands, or active sand dunes.

About 35 percent of the study area has soils useable as planting media. Most bedrock is presently unuseable as planting media.

Coalbeds average about 5.4 feet in thickness and depth of overburden (above the upper coalbeds) varies from less than 10 feet to more than 260 feet.

Main use of the study area is for livestock grazing. Some livestock owners live on the land, some temporarily, and some permanently. The study area is also used as access to Chaco Canyon National Monument. Some wildlife use the study area, but species are limited because of the harsh environmental conditions.

---

* This is the study area established by BLM. Some study areas shown in this report may be slightly different.

SECTION B

CLIMATE

SECTION B

CLIMATE

Distant high mountains shield this area from shallow intrusions of extremely cold air in winter. Mountains also block the area from much Pacific air precipitation; and before it reaches northwestern New Mexico, air from the Gulf of Mexico loses most of its moisture. This lack of precipitation is an important aspect of the climatic picture which emerges from the data that follows. The Kimbeto study area is in an area where all climatic factors typical of the semiarid plains grasslands are found.

Chaco Canyon National Monument is the nearest long-term meteorological station to the Kimbeto study area. It is located about 8-1/2 miles south of the study area at an elevation of 6,175 feet. All climatological data from this weather station are assumed to be directly applicable to the study area, which is at an altitude averaging 6,300 feet.

Temperature

Based on data from this station, the Kimbeto study area has an average annual temperature of 49.7° F. Average monthly temperatures (° F) for the study area are as follows:

January	27.5	July	73.1
February	33.5	August	70.8
March	39.5	September	62.8
April	48.0	October	51.3
May	57.0	November	37.6
June	66.5	December	29.0

Extreme temperatures in San Juan County are 110° F and -35° F. Temperatures rarely reach 100° F, however, and only a few days a year, fall to zero or below. The average daily range of temperatures is about 33° F. Frequent freezing and thawing of the surface takes place in December through March when nighttime temperatures average below freezing.

Freeze data for the Kimbeto study area were based on the 1966-1975 records for Chaco Canyon, which are summarized in table B-1.

Precipitation

Average annual precipitation at Chaco Canyon is about 8.8 inches. Monthly precipitation for the study area in inches is as follows:

January	0.39	July	1.19
February	0.52	August	1.41
March	0.60	September	1.15
April	0.40	October	1.04
May	0.60	November	0.47
June	0.38	December	0.61

Table B-1
Study Area Freeze Data
Chaco Canyon (Elevation 6,175)
(degrees F)

	Date last spring Minimum of			Date first fall Minimum of			No. of days between dates		
	24°	27°	32°	32°	28°	24°	24°	28°	32°
Earliest	4/21	4/30	5/16	8/21	8/24	8/29			
Latest	5/23	6/26	6/26	10/9	10/15	10/16			
Average	5/11	5/29	6/5	9/19	9/26	10/2	145	120	106

As can be seen, half of the annual precipitation occurs in late summer and early fall when thunderstorms are most active. These are localized, often intense storms, which can cause flash flooding and heavy erosion.

Some variations are expected in these average values. Near the study area, annual precipitation ranges from about 3 to 14 inches.

The amount of total precipitation which is effective can be directly related to intensity of precipitation. Generally, effective precipitation is determined on a monthly basis with the first inch considered 95 to 100 percent effective. Determining effective precipitation this way, on an average basis, the annual precipitationof 8.8 inches at the Kimbeto study area appears to be close to 7 inches of effective precipitation. Under certain soil and slope conditions--such as soils with low infiltration rates and steep slopes--this figure will be much less. These conditions are common at the study area.

The snowfall season is November through April, with an annual average total of about 9 inches. Hail occurs occasionally in association with the late summer and early fall thunderstorms.

Other climatic characteristics

While winds at higher altitudes move generally from west to east, surface winds are greatly modified by local topography. During much of the year, high-pressure systems and fair weather are dominant; calms are frequent but usually short in duration. Surface winds move up the valley slopes during the day and down the slopes at night. Spring is the windiest season, with winds averaging 10 miles per hour. Wind speed is highest, however, during the summer months. Strong winds up to 25 miles per hour are most common from the west. Very strong

winds, occasionally up to 70 miles per hour, are associated with local thunderstorms, and thus are of short duration. In the San Juan Basin, particularly in the Chaco River drainage area, the dry exposed topsoil, scanty vegetation, and turbulent winds cause much blowing dust during the dry months from November to April. Dust devils, vertical vortexes of rapidly moving dust-laden air, are common in the summer.

Average relative humdidity is nearly 50 percent, ranging from 70 percent in early morning to 30 percent in the afternoon. In late spring and early summer, afternoon relative humidities are 15 to 20 percent.

Pan evaporation at Farmington is 49 inches annually. It may be as much as 25 percent greater at higher plateau locations where there is greater wind movement.

Effect of weather on site revegetation

Several weather-related factors will definitely have adverse effects on revegetation of the Kimbeto study area. Low annual precipitation rates compounded with erratic distribution patterns and high summer storm intensities create unfavorable conditions for unadapted seed germination species and plant growth. The effectiveness of the incoming precipitation is further reduced by the occurrence of shallow soils over some of the area and by relatively low soil infiltration rates. Strong spring winds tend to remove soil moisture that could other wise be utilized in seed germination, seedling establishment, and general plant growth. Dry, cold, windy winters may also result in relatively high percentages of winterkill among recently established vegetation.

Climate and aspect (exposure)

South-facing slopes at the study area will characteristically be subjected to more droughty conditions than slopes with northern aspects or exposures. These droughty conditions result primarily from the prevailing dry west and southwest winds and from higher temperatures due to greater amounts of incoming solar radiation. Soil movement due to wind erosion may expose the tender roots of plant seedlings or bury the seedlings entirely.

Evapotranspiration demand

The Kimbeto study area has an estimated annual pan evaporation rate of about 55 inches, and an annual precipitation rate of only 8.8 inches. High temperatures, low precipitation rates, low humidities, and regular winds result in plant moisture deficits far exceeding available annual moisture levels. This is especially true during the summer growing season. Therefore, revegetation of the study area must be accomplished using native plant species characteristic of the immediate area which have shown the adaptations or inherent abilities to withstand the high summer moisture deficits.

SECTION C

PHYSIOGRAPHY, RELIEF, AND DRAINAGE; GEOLOGY

SECTION C
PHYSIOGRAPHY, RELIEF, AND DRAINAGE; GEOLOGY

Physiography, Relief, and Drainage

The study area is situated in the Navajo Physiographic Section of the Colorado Plateau Physiographic Province, which in turn is in the Intermontane Plateaus, a major physiographic division of the United States.

The Navajo Physiographic Section comprises a large region of northwestern New Mexico and northeastern Arizona. The bold contrasts of the section's landforms are characterized by young plateaus, mesas, hogbacks, retreating escarpments, and debris-choked dry wash canyons. Though there are numerous cliffs and escarpments, talus accumulations are rare. Precipitation is low to moderate, the latter at the higher elevations. The sections's San Juan River is the only stream which collects runoff from outside the section. Vegetation consists mostly of sagebrush, bunchgrasses, and their associates. In places vegetation gives way to bare soil, bare-rock badlands, or active sand dunes.

The physiographic subdivision of the Navajo Section which contains the study area is the Chaco Plateau. Boldly scarped, rolling, broad plains and mesas characterize the the Chaco Plateau. Youthful canyons of badland topography indent the abrupt escarpments bordering the uplands. Wide swales trenched by sand-choked dry wash canyons area starkly cut into the plains. The effects of erosion by wind and water are graphically evident, and landforms are determined by the relative resistance and attitude of the rock formations.

The study area is an area of sharp contrasts, including badlands, boldly scarped pinnacles and small mesas, sand dunes, sand-choked dry washes, and terrace ridges. (Figure C-1 shows the topography of the study area; figure F-1 shows the location of major topographic features.) The more dominant topographic features are the Quaternary terrace ridges that parallel the southwest trending Ah-shi-sle-pah, Kimbeto, and Betonnie Tsosie Washes. The Quaternary alluvium in the dry washes is generally flanked by older alluvium and sand dunes, both active and inactive. The thin veneer of aeolian sand mantling the terrace ridges and the dune sand in the wide channels of the washes support some sparse vegetation and soil cover, which contrasts with the stark but scenic intricately eroded barren badlands. Badlands occur in the northwest portion of the study area, adjacent to Ah-shi-sle-pah Wash.

Major drainage near the study area is west and southwest from Kimbeto, Betonnie Tsosie, and Escavada Washes to the Chaco River, a left tributary to the San Juan River. These major washes drain into Chaco Canyon, which has a gradient of about 40 feet per mile.

Thin to nonexistent soil cover and vegetation, the poorly pervious nature of some of the soils and underlying rock formations, and relative steep gradients are primary factors which could result in high runoff. Infrequent but sometimes

intense rainstorms change the otherwise dry channels of Kimbeto, Betonnie, and Escavada Washes to raging sediment-laden torrents.

The steepest gradients are about 85 feet per mile in the northwestern portion of the study area, adjacent to Ah-shi-sle-pah Wash, where the poorly pervious Kirtland shales show evidence of rapid erosion resulting in badland topography.

Geology

Regional geology

The major structural element of the region which includes the study area is the San Juan Basin--a circular, intermontane, structural element encompassing a large region in northwestern New Mexico and southwestern Colorado. Structural elements of the basin are shown on figure C-2. The basin is one of several interspersed or embayed into the ranges of the Rocky Mountains between New Mexico and Canada. The boundaries of the basin are in places sharply defined by monoclinal folding and associated hogbacks, or by faulting, while in other places the basin merges into adjoining depressions or uplifts. The basin is asymmetric, its axis being located in the northeast quadrant of its Central Basin. The Central Basin has a broad south limb dipping gently northeast, on which the study area is situated, and a narrower, more steeply dipping north limb. Thus, the study area is in the southwestern quadrant of the Central Basin of the San Juan Basin. The rocks within the Central Basin and study area predominantly are clastic sedimentaries of Late Cretaceous and Tertiary ages. They are undisturbed by faulting, though a few broad folds with gentle dips are reported. Gas production within the Central Basin is largely from stratigraphic traps.

The San Juan Basin contains clastic and minor chemical sedimentary rocks ranging in age from Cambrian to Quaternary, having a maximum total thickness exceeding 14,000 feet in the deepest or axial northeastern part of the basin. The nomenclature, ages, and surface distribution of the rocks pertinent to the study area are shown on figure C-3.

The varied rock sequence of the San Juan Basin reveals many cycles of marine and nonmarine deposition. A complex sequence of Paleozoic-age sandstone, conglomerate, limestone, shale, gypsum, and a number of unconformities attest to alternating cycles of submergence and emergence. During the Mesozoic era, the San Juan Basin was primarily an emergent area at which time fluviatile sediments of sandstone and shale were deposited. During the early part of the Late Cretaceous period, however, seas advanced across the area, depositing the transgressive Dakota Sandstone and the marine Mancos and Lewis Shales. The onset of the Laramide orogeny in the late Cretaceous period resulted in a retreat of the sea and deposition of the regressive Pictured Cliffs Sandstone. The superjacent Fruitland Formation contains carbonaceous shale, sandstone, siltstone, and coal which were laid down in swamp and flood plain environments on coastal lowlands adjacent to the eastward-retreating Cretaceous sea. The

Photo C-1. Looking southeast from DH-1K toward a terrace ridge in the background. (See figure C-7 for locations of DH's.)

Photo C-2. Looking north from DH-3K at a partially stabilized sand dune in the foreground and badlands (Kirtland Formation) in the background.

KIMBETO STUDY AREA

CHACO CANYON NATIONAL MONUMENT

Wash

Kimbeto

Tsoste

Betonnie

Escavada

Hollow Pit Tank

Tony Lopez Well

Sleepy Grass Dam

Indian Ruins

Chaco Canyon Trading Post

Canyon

2000 0 6000

SCALE OF FEET

N

ALWAYS THINK SAFETY

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

EMRIA REPORT NO. 17-77

KIMBETO STUDY AREA - NEW MEXICO

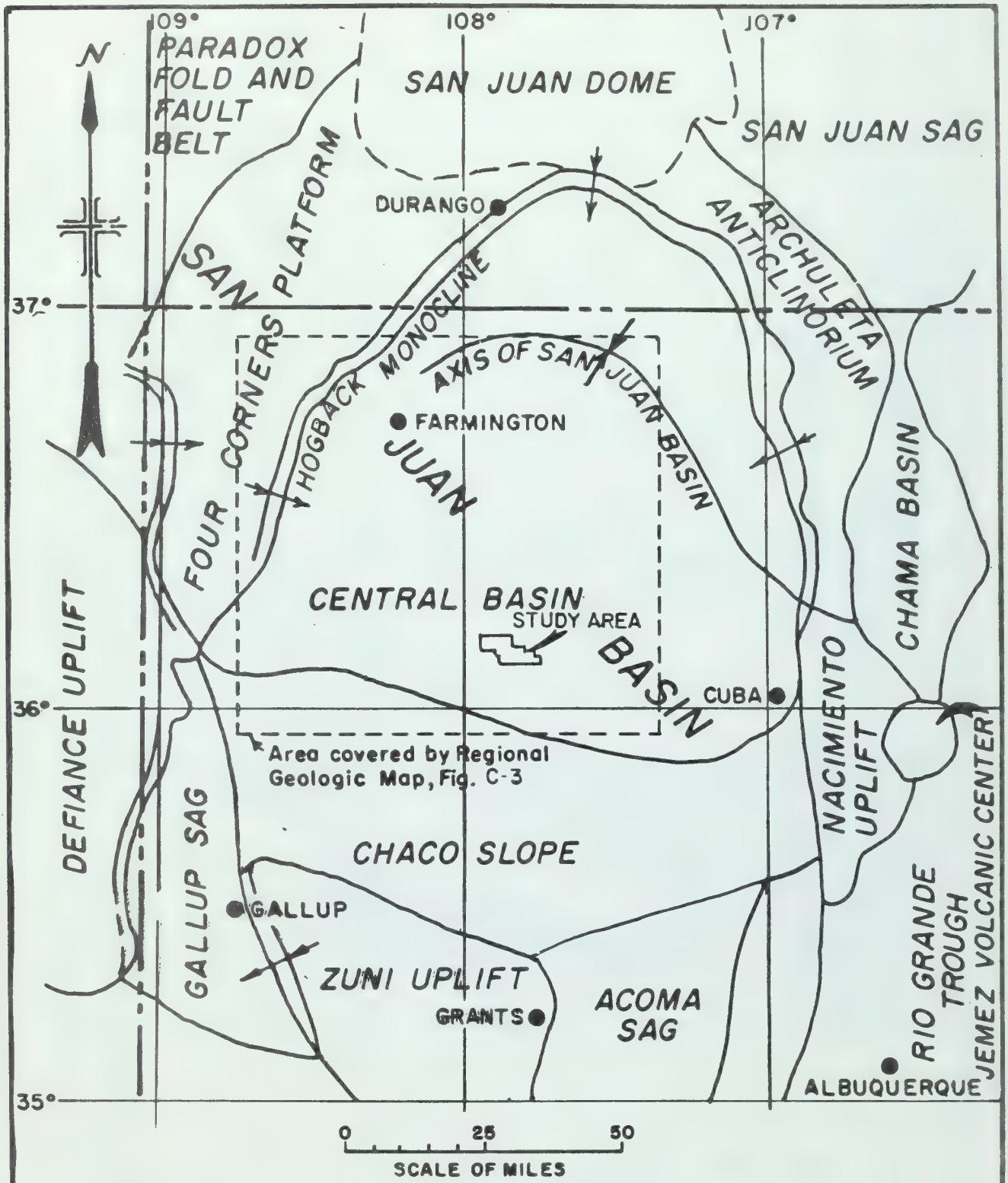
TOPOGRAPHY

DESIGNED _____ SUBMITTED _____

DRAWN _____ RECOMMENDED _____

CHECKED _____ APPROVED _____

Figure C-1



NOTE:
Drawing adapted from U.S. Geological Survey Professional Paper 552, Figure 5

STRUCTURAL ELEMENTS OF SAN JUAN BASIN

FIGURE C-2

EXPLANATION

TERTIARY — Non-Marine

Tsj SAN JOSE FORMATION: Massive, thick-bedded sandstone and interbedded lenticular shale.

Unconformity

Tip Shale and sandstone. In part equivalent to Kin and Kta.

CRETACEOUS — Marine and Non-Marine

Kin NACIMIENTO FORMATION: Varicolored shale, siltstone, and mudstone with interbedded and lenticular sandstone and conglomeratic sandstone, in the east. Animas formation (Kta) equivalent in the northeast.

Disconformity

Koa OJO ALAMO FORMATION: Massive sandstone, conglomeratic sandstone, conglomerate, and minor shale.

Disconformity

Kmd MCDERMOTT FORMATION: Shale, sandstone, and volcanic debris.

Kk & Kkf KIRTLAND FORMATION: Includes upper and lower shale members (Kk), and the Farmington sandstone middle member (Kkf).

Kf FRUITLAND FORMATION: Massive carbonaceous shale, sandstone, siltstone, and coal.

Kpc PICTURED CLIFFS FORMATION: Predominantly sandstone with minor shale and siltstone.

Kl LEWIS FORMATION: Predominantly shale with minor thin siltstone and sandstone.

Kmv MESAVERDE GROUP, UNDIFFERENTIATED: Shale, sandstone, siltstone, and coal. Includes Mancos shale and Dilco coal and Gallup sandstone members (Kgd).

Kd DAKOTA SANDSTONE: Sandstone with conglomerate at base locally.

Unconformity

JURASSIC

Ju JURASSIC UNDIFFERENTIATED: Includes variegated shale and sandstone, limestone and gypsum.

Unconformity

TRIASSIC

Tr TRIASSIC UNDIFFERENTIATED: Includes Chinle shale and other mappable local units to the east; to the west and south may include equivalents of the Shinarump Conglomerate and Moenkopi formation.

Disconformity

PERMIAN

Pu PERMIAN UNDIFFERENTIATED: Limestone, gypsum, sandstone and evaporites in the south; grades to red beds to the north.

PENNSYLVANIAN

CP PERMIAN AND PENNSYLVANIAN UNDIFFERENTIATED

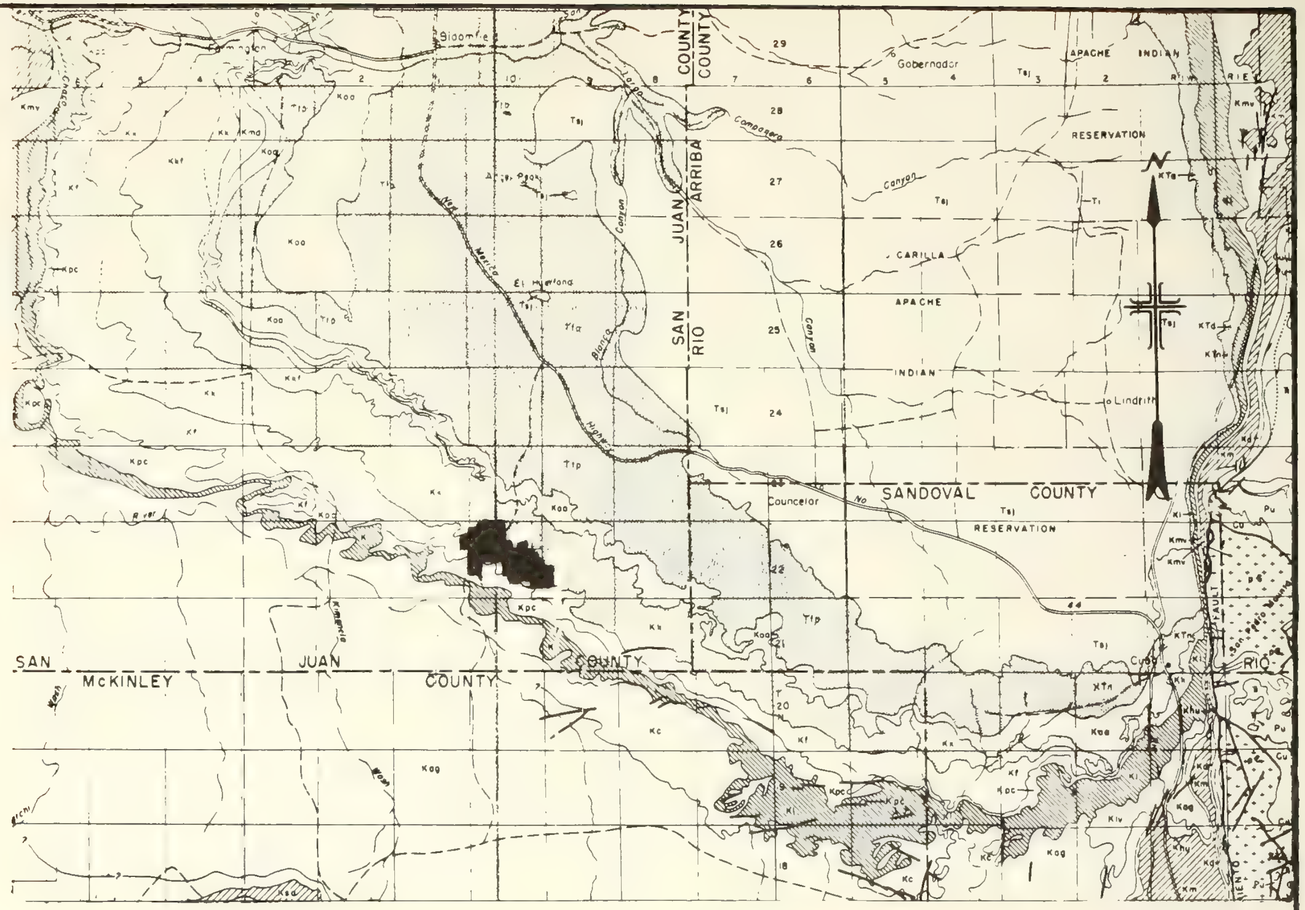
Cu Limestone, sandstone, and shale.

Non-conformity

CRYSTALLINE ROCKS

Tv TERTIARY VOLCANICS

PC PRE-CAMBRIAN: Granite, gneiss, schist and quartzite.



0 5 10 15 20 25 30

SCALE OF MILES

NOTE: Reproduced in part and adapted from: New Mexico Geological Society Guidebook of the San Juan Basin, First Field Conference, 1950, Geologic Map of the San Juan Basin, by Caswell Silver.

EMRIA REPORT NO. 17-77
KIMBETO STUDY AREA - NEW MEXICO
REGIONAL GEOLOGY

FIGURE C-3

Kirtland Shale, which overlies the Fruitland Formation, consists of upper and lower shale members and a middle sandstone member, which respectively represent swamp, flood plain, and channel deposits. As the Cretaceous period closed, increasing orogenic activity and vulcanism flooded the San Juan Basin area with detritus and volcanic debris, which constitute the McDermott Member and other parts of the Animas Formation and parts of the Ojo Alamo Sandstone. Orogenic and volcanic activity continued well into Paleocene time in the Cenozoic era, as evidenced by andesitic detritus of the Animas Formation and fluviatile sands and silts of the Nacimiento Formation. A late episode of this orogenic activity is evidence by the Eocene-age San Jose Formation, a "basin-filling" sequence of sandstone and shale derived from rising fold belts to the east, north, and west. During this episode, the prominent structural features of the basin rim were formed, including the Gallup Basin, Defiance Uplift, Hogback Monocline, Archuleta Anticlinorium, and Nacimiento Uplift. In late Cenozoic time the San Juan Dome was formed by volcanic activity and emplacement of intrusive igneous bodies contemporaneous with elevation of the San Juan Basin area. In relatively recent geologic time erosion by water, wind, and glaciation has developed the present landscape, characterized by buttes, mesas, and dry-wash canyons in the basin, and by hogbacks, ridges, and mountains on the rims.

Study area geology

Investigations. Ten Nx-size (3-inch diameter) core holes, designated DH-1 through DH-10, were drilled at the study area. Locations of the holes are shown on figures C-4 and C-7.

Three of the holes (DH-1, DH-5, and DH-10) were deepened approximately 200 feet each for ground water studies by the GS. Two-inch-diameter perforated plastic pipe was installed in these holes. Geophysical logging of the holes was done by GS.

Continuous Nx-size coring was done from the top of formation rock to depths sufficient for penetration of all beds of coal in the Fruitland Formation and into the underlying Pictured Cliffs Formation. Celex Condet drilling mud and water were used as the drilling medium; and a sodium base (Barafos) and mud was also used in DH-5, 7, and 10 to settle out the cuttings. Overall core recovery was good. Core recovery was 100 percent in all beds of coal, except in DH-3 between depths of 134.0 and 141.0 feet, where 98 percent was recovered; in DH-4 between depths 265.0-290.0 feet, and 294.2-303.5 feet, where 99 percent and 88 percent were recovered respectively; in DH-6 between depths 284.0 and 285.1 feet where there was no recovery; and in DH-10 between depths 183.1-185.1 feet, 281.0-288.4 feet, where 91 percent and 35 percent were recovered respectively. All coal samples were sealed in plastic bags immediately after removal from the core barrel and were shipped to the GS, Denver, for testing and analysis. For each core hole, two samples (each 10 to 12 pounds) of each lithologic unit were thoroughly cleaned to remove the drill-mud coating, sacked, and shipped to the BR laboratory, Lower Missouri Region, Denver, Colorado, for physical and chemical analyses. The remainder of the core samples were stored at the BLM

warehouse, Farmington, New Mexico. Samples of drilling mud and water used in drilling were collected and furnished to the GS and BR Denver offices. 1/

The study area geologic map, figure C-4, was compiled by Intrasearch, Denver, Colorado, using aerial photo interpretation, on a GS7.5-minute quadrangle topographic base. Some minor modifications were made by Gary B. Schneider, USGS/BLM while field checking the map.

Geology. Surficial materials in the study area consist of sandy, silty, clayey terrace ridges between and adjacent to Kimbeto, Betonnie, and Escavada washes, and active to partially stabilized dunes of silty sand and silty to slightly clayey older alluvium mantle most of the slopes adjacent to the washes. The development of sedentary soils and vegetative growth has been retarded or precluded over a relatively large area in the northwestern portion of the study area due to unfavorable chemical constitutents in much of the underlying formation rock. Moisture infiltration rates and retention capabilities of the soils are also probable factors in the retardation or preclusion of the development of vegetative growth. These barren areas appear as badlands intricately carved by wind and water erosion.

The late Cretaceous age sedimentary rock formations outcropping over much of the study area belong, in ascending order, to the Pictured Cliffs Sandstone, Fruitland Formation, and Kirtland Shale. The formations dip to the northeast, toward the axis of the San Juan Basin, at angles of less than 2 degrees; consequently, the Pictured Cliffs Sandstone which outcrops immediately south of the study area is succeeded successively northeastward in the area, or downdip, by the outcrop belts of the younger Fruitland Formation and Kirtland Shale. Outcrops of the formations are delineated on figure C-4.

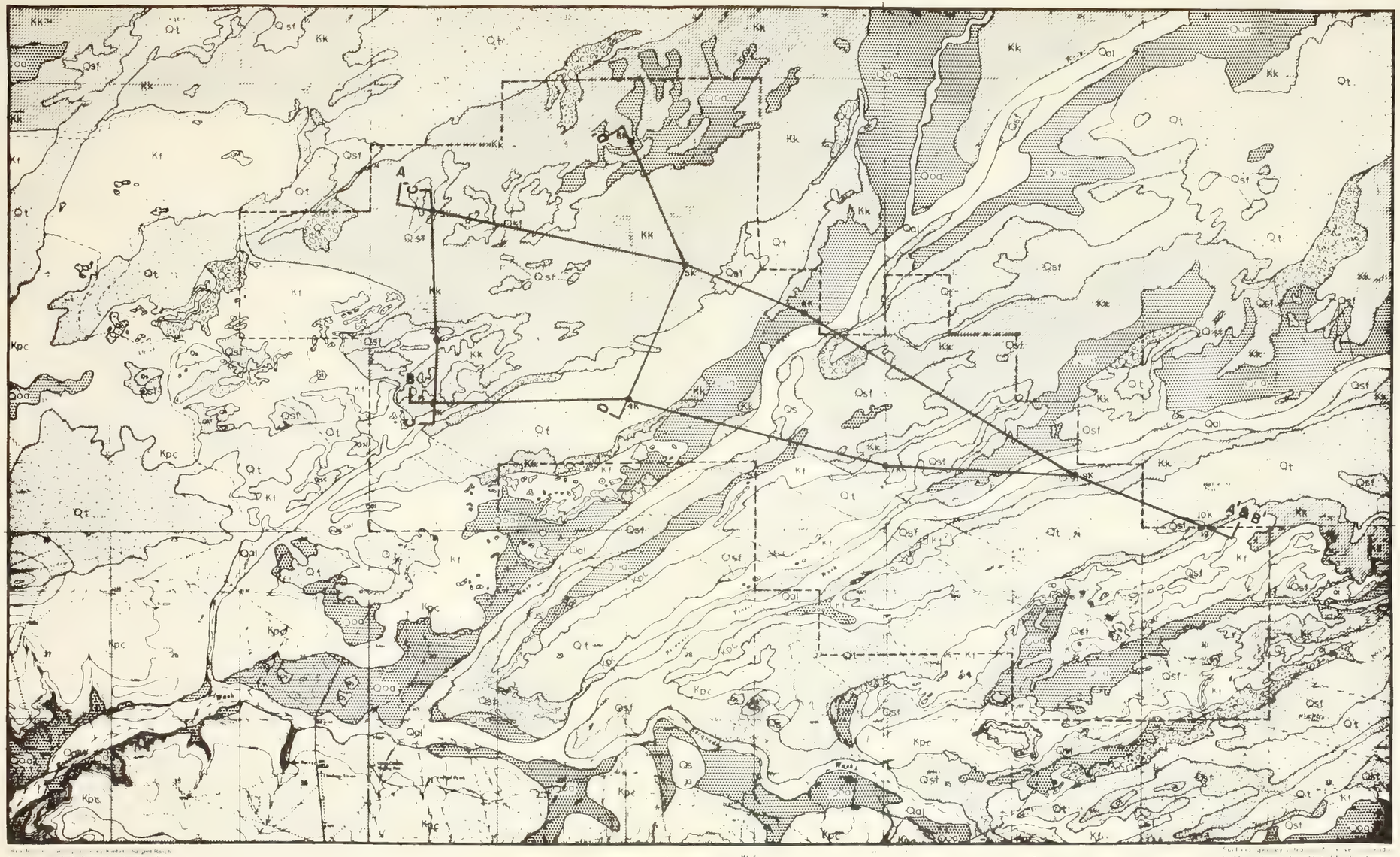
The Pictured Cliffs Sandstone is underlain by the Lewis Shale of Late Cretaceous age, which consists of beds of clayey, silty shale, and minor thin sandstone, ranging from 200 to 500 feet in total thickness. The Lewis Shale in turn rests on sedimentaries of shale, sandstone, coal, limestone, gypsum, salt, and quartzite more than 10,000 feet in total thickness that range in age from Cambrian to Late Cretaceous.

The Pictured Cliffs Sandstone in the study area consists predominantly of fine-to-medium-grained sandstone which is silty and slightly clayey, weakly cemented and friable, massively bedded, and light gray to light greenish gray. Minor thin beds of siltstone and shale are reported in the literature. The lithology and fossils of the formation indicate the rocks were deposited in littoral and offshore marine environments at a time when the shoreline of the Cretaceous sea was regressing northeast across the area. The Pictured Cliffs Sandstone is considered one of the most important gas-producing formations in the central and northern parts of the San Juan Basin.

1/ Cores were also made available to GS for geochemical analysis (see section F).

Photo C-3. Looking northeast from DH-4K along a crest of a terrace ridge. A Navajo home is in the background.

Photo C-4. Looking west at DH-5K, in the badlands (Kirtland Formation).



EXPLANATION

QUATERNARY

- Qal — ALLUVIUM
- Qs — ANC. ACTIVE DUNE
- Qsf — ANC. FIXED DUNE
- Qc — COLLUVIUM
- Qt — TERRACE, LAG GRAVEL & EOLIAN SAND
- Qaa — RECENT ALLUVIUM

CRETACEOUS

- Kk — KIRTLAND SHALE
- Kf — FRUITLAND FORMATION (WITH LOWER, MIDDLE, AND UPPER COAL ZONES; TOP OF UPPER COAL ZONE IS TOP OF FRUITLAND, BASE OF LOWER COAL ZONE IS BASE OF FRUITLAND)
- Kpc — PICTURED CLIFFS SANDSTONE

BOREHOLE

GEOLOGIC CONTACT

BASE OF COAL ZONE, POSITION APPROXIMATE

PROJECTED WHERE CONCEALED

SOCIETY

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
EMRIA
KIMBETO STUDY AREA

RESOURCE AND POTENTIAL RECLAMATION EVALUATION
GEOLOGIC MAP AND LOCATION OF EXPLORATION

DESIGNED — SUBMITTED
DRAWN — RECOMMENDED
CHECKED — APPROVED

DWG. NO. TEXAS — MARCH 1978 — Figure C-4

The contact between the Pictured Cliffs Sandstone and the overlying Fruitland Formation is arbitrarily placed at the top of the uppermost massive sandstone in the Pictured Cliffs Sandstone, below the lowermost coal in the Fruitland Formation. Coring at drill holes DH-1, DH-5, and DH-10 penetrated 122.7 to 148.7 feet of the upper part of the Pictured Cliffs Sandstone, while considerably less footage was cored at the other drill holes.

Overburden materials in the Fruitland Formation and Kirtland Shale and materials separating the Fruitland coal beds consist of shale, sandstone, and siltstone. The shales are clayey to silty, locally betonitic and gypsiferous, carbonaceous in part, firm to soft, earthy and crumbly, fissile or laminated to massive bedded, gray, dark gray, black, or brown. Slickensided fractures are common. The sandstones are fine-grained, silty, slightly clayey, limy, carbonaceous in part, laminated to massive bedded, soft to weakly cemented and friable, locally moderately hard, light gray to gray or dark gray. The siltstones are clayey, fine sandy, carbonaceous in part, laminated to massively bedded, firm, gray to light gray. Hard ferruginous-cemented concretions up to 2 feet in diameter occur in the Kirtland Shale.

The Fruitland Formation consist predominantly of shale, sandstone, siltstone, and coal. Thin beds of limestone are reported in the geologic literature to occur from place to place in the lower part of the formation; however, none were cored in drill holes at the Kimbeto study area. The formation was laid down in flood plain and swamp environments; consequently, most rock units are discontinuous. Individual beds thicken, thin, and pinch out laterally, often within a few hundred feet. The coal beds are the most continuous lithologic units and in places can be traced for several miles. The coal beds are thicker and more numerous in the lower one-third of the formation. Sandstone is usually more abundant in the lower part of the formation, while shale and siltstone are more abundant in the upper part. Based on the geologic logs for DH-1 through DH-10, shale makes up an average of roughly 25 percent of the formation, coal about 25 percent, sandstone about 35 percent, and siltstone about 15 percent. A bed of bentonitic shale was cored in DH-9 between depths 174.5 and 176.7 feet.

The contact of the Fruitland Formation with the overlying Kirtland Shale is arbitrarily placed at the top of the highest coal or carbonaceous bed in the Fruitland Formation. The Fruitland Formation was found to have the following thicknesses (feet): DH-10, 226.5; DH-9, 192.0; DH-3, 185.4; DH-6, 153.9; DH-1, 152.0; DH-8, 127.9; DH-7, 123.4; DH-2, 115.4; DH-4, 113.6; and DH-5, 90.4.

The Kirtland Formation in the San Juan Basin has been divided into three members--the lower shale member, the Farmington Sandstone or middle member, and the upper shale member. Only the lower shale member is evident in the study area, where most of the formation has been removed by erosion or was not deposited. According to the defined contacts, the Kirtland Formation was cored to a depth of 260.9 feet at DH-5. Subsequent analysis of the material in the interval from 61.9 to 63.5 did not prove to be coal as shown on the field log. The geolgic log for DH-5 indicates the Kirtland Formation consists of roughly 35 percent shale, 55 percent sandstone, and 10 percent siltstone.

Interpretive east-west and north-south stratigraphic hole-to-hole correlations of the various formational contacts and coal beds are shown on figures C-5 and C-6, Diagrammatic Geologic Sections. Figure C-7 shows thickness of overburden at the study area.

Acquifers. No recognizable aquifers or other significant ground water bodies were noted during coring or during drilling operations which deepened DH-1, DH-5, and DH-10 to depths of 300.5, 474.0, and 500.0 feet respectively. Moreover, the generally fine-grained nature of the formation rock and lack of fracture or other types of permeability would generally preclude the presence of significant aquifers to the explored depths. Some minor free water was noted in the coal zones of the Fruitland Formation. Minor quantities of perched ground water occur in the Central Basin of the San Juan Basin in some areas in relatively shallow sandstone bodies. Low annual precipitation; high runoff; high evaporation; and terrain consisting of mesas, narrow ridges, high cliffs, and deep canyons usually limit infiltration to these bodies. No springs or seeps were noted in the study area. More discussion of ground-water-bearing units at the study area may be found in section J.

Engineering geology. The shale, sandstone, and siltstone constituting overburden in the lower member of the Kirtland Shale and overburden and material separating coal beds in the Fruitland Formation are similar in engineering properties. Rock in both formations is firm to only weakly cemented except for minor ferruginous-cemented concretions and thin beds. All excavation would be classed as common; however, blasting would facilitate excavation.

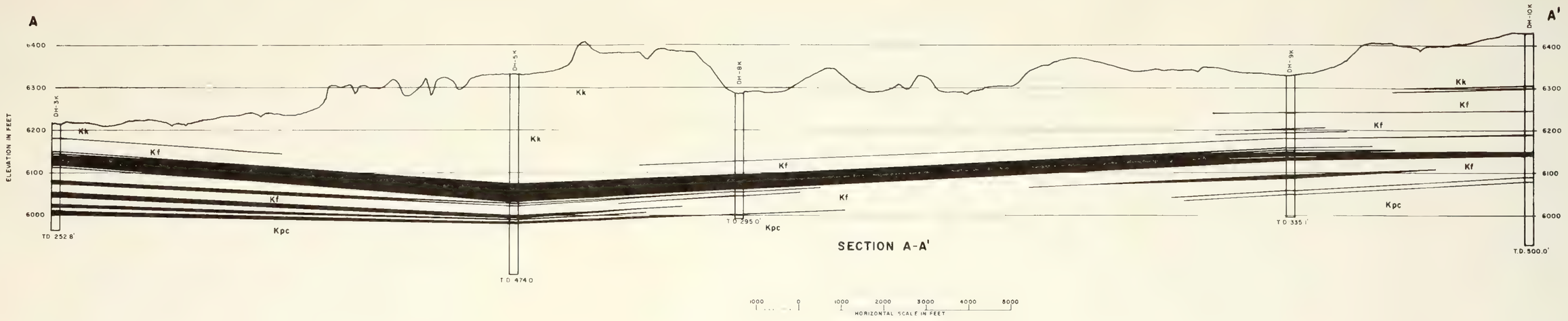
Excavations in the Kirtland Shale and Fruitland Formation would stand on near-vertical slopes for several months. Minor ravelling of slopes could be expected as the materials dry and air-slake. Stability of slopes is expected to decrease with the increased moisture of wet weather (see Results of Weathering Tests, Section Q).

Haul roads surfaced with spoil material would be unusually slick and difficult to travel during periods of wet weather. Haul roads would be unusually soft during periods of alternate freezing and thawing, particularly in the spring, and would require continuous maintenance.

Photo C-5. Looking north from DH-8K toward a terrace ridge (extreme background) overlying the Kirtland Formation.

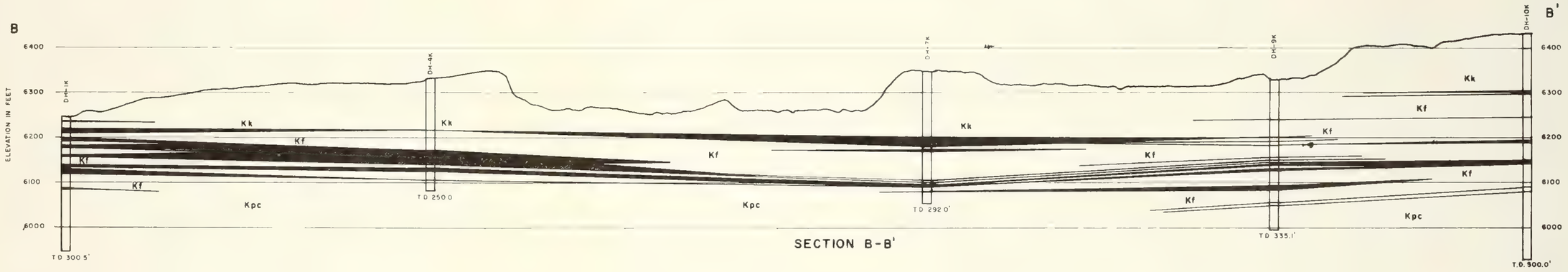
Photo C-6. Looking north from DH-9K at a stabilized sand dune (background) near Betonnie Tsosie Wash.

Photo C-7 Looking south from DH-10K, located on a terrace ridge (foreground), toward the badlands (background).



SECTION A-A'

1000 0 1000 2000 3000 4000 5000
HORIZONTAL SCALE IN FEET



SECTION B-B'

EXPLANATION

Kk = Cretaceous Kirtland Shale, Lower Member. Predominantly shale with lesser amounts of interbedded sandstone and siltstone.

Kf = Cretaceous Fruitland Formation. Predominantly shale, organic shale, and coal. Lesser amounts of interbedded sandstone and siltstone.

Coal Bed. Hole-to-hole correlations are interpretive.

Kpc = Cretaceous Pictured Cliffs Sandstone. Predominantly sandstone with minor interbeds of shale.

Geologic Contact. Hole-to-hole correlations are interpretive.

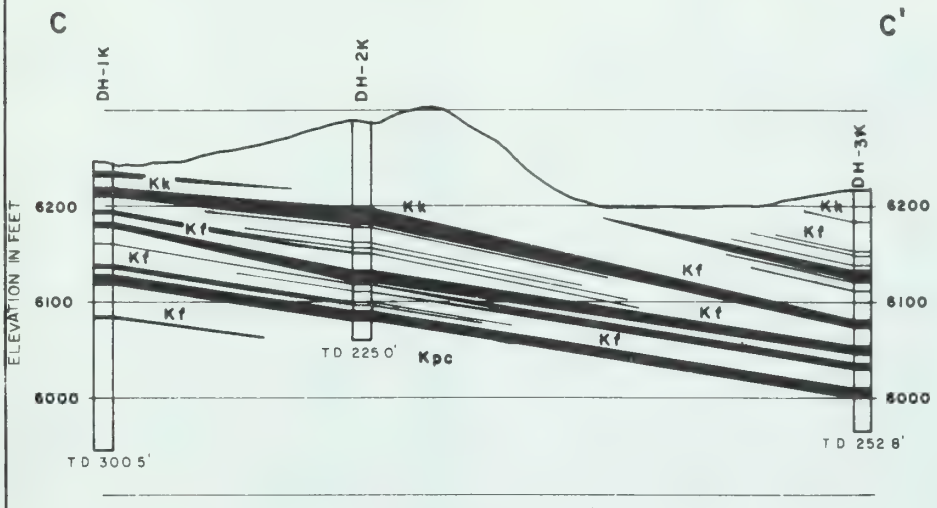
T.D. = Total depth of hole.

For locations of sections, see Figure C-4

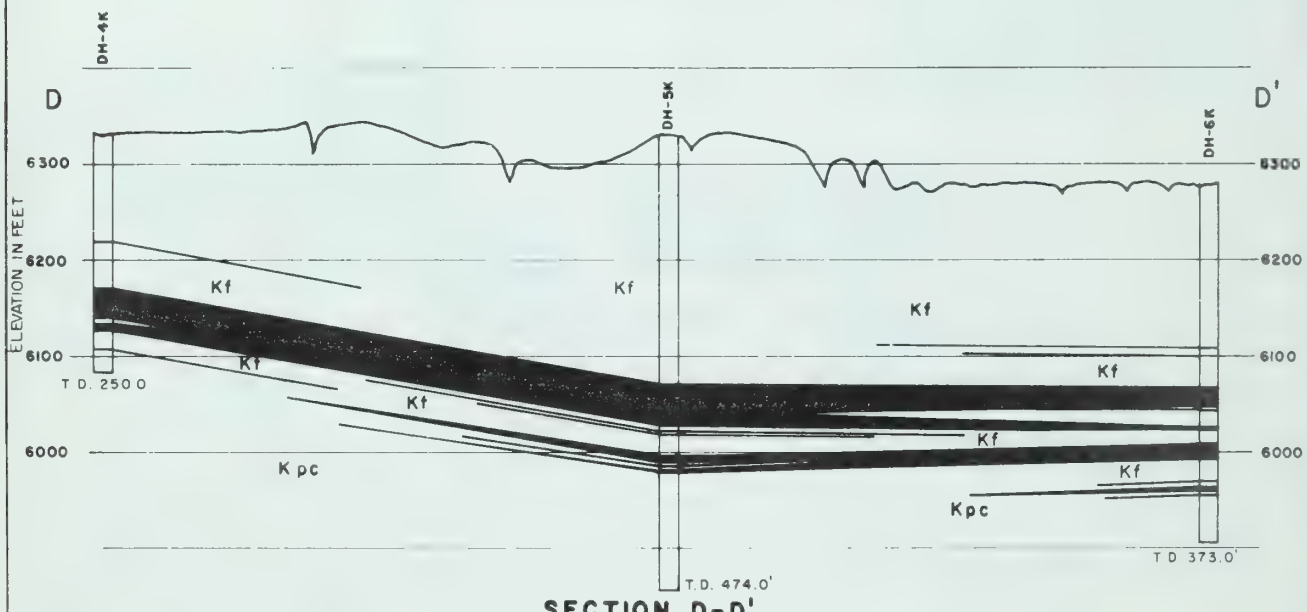
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

EMRIA REPORT NO. 17-77
KIMBETO STUDY AREA-NEW MEXICO
DIAGRAMMATIC GEOLOGICAL SECTIONS

Figure C-5



SECTION C-C'



SECTION D-D'

EXPLANATION

Kk = Cretaceous Kirtland Shale, Lower Member, Predominantly shale with lesser amounts of interbedded sandstone and siltstone.

Kf = Cretaceous Fruitland Formation, Predominantly shale, organic shale, and coal. Lesser amounts of interbedded sandstone and siltstone.

Coal Bed. Hole-to-hole correlations are interpretive.

Kpc = Cretaceous Pictured Cliffs Sandstone, Predominantly sandstone with minor interbeds of shale.

Geologic Contact. Hole-to-hole correlations are interpretive.

T.D. = Total depth of hole.

For locations of sections, see Figure C-4

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

EMRIA REPORT NO. 17-77
KIMBETO STUDY AREA - NEW MEXICO
DIAGRAMMATIC GEOLOGICAL SECTIONS

Figure C-6

R11W - R10W

R10W - R9W

T23N
T22N

DH-6K
350'

DH-3K
250'

DH-5K
525'

Kimbeto Study Area

DH-8K
300'

DH-2K
225'

DH-4K
250'

DH-1K
350'

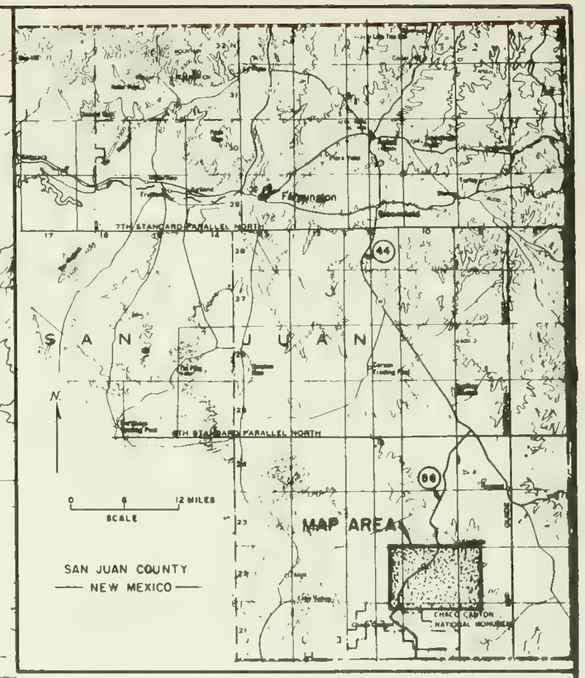
DH-7K
200'

DH-9K
350'

DH-10K
350'

T22N
T21N

CHACO CANYON NATIONAL MONUMENT



LOCATION MAP

NOTE:
Total depths of the drill holes are indicated. The indicated depths include drilling and sampling without coring, 3 inch diameter, between the following approximate depth intervals in the following drill holes:

DRILL HOLE	APPROX. DEPTH INTERVALS
DH-1K	150'-350'
DH-5K	375'-525'
DH-10K	350'-550'

N

2000 0 8000
SCALE OF FEET

——— Thickness Of Overburden (50' Contours)

——·—·— Structure Contour On Top Of Coal

○ Drill Hole Locations & Total Depths

ALWAYS THINK SAFETY

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

EMRIA REPORT NO. 17-77
KIMBETO STUDY AREA-NEW MEXICO

OVERBURDEN THICKNESS MAP

DRAWN ..... SUBMITTED .....
TRACED ..... RECOMMENDED .....
CHECKED ..... APPROVED .....

Figure C-7

SECTION D

COAL RESOURCES

SECTION D

COAL RESOURCES

For a general discussion of coal origin, classification, rank, type, and grade, see Section O.

Most of the coal in the Kimbeto area is in the lower 150 feet of the Upper Cretaceous Fruitland formation. The Fruitland is a sequence of highly lenticular non-marine claystone, silty and sandy shales, and cross-bedded sandstones, with coal; the overlying Kirtland Shale is of similar lithology but lacks coal. The Fruitland is underlain by the marine Pictured Cliffs Sandstone, also of Late Cretaceous age.

Fourteen samples listed on tables D-1 and D-2 show an apparent rank that ranges from subbituminous B to subbituminous A. Because of the lack of definitive information about the distribution of coals of various groups in the Fruitland coal, it is considered to be all between subbituminous B and subbituminous A in rank in the area of the study.

The ash and sulfur content of the 14 coal samples from the Fruitland coal, as-received, are ash range, 9.3 to 33.2 percent, averaging, 23.4 percent; sulfur-range 0.4 to 0.7 percent, average, 0.5 percent.

Estimation and classification of coal resources

Coal resource estimates have been prepared for the Fruitland coal within the Kimbeto EMRIA study site using standard procedures, definitions, and criteria established by the U.S. Geological Survey and U.S. Bureau of Mines for making coal resource appraisals in the United States. The term "coal resources" as used in this report means the estimated quantity of coal in the ground in such form that economic extraction is currently or potentially feasible.

Tabulation of estimated coal resources

Tables D-3 and O-2 summarize the estimated coal resources of the Kimbeto EMRIA study site. The resources in the study site are classed as measured, indicated, and inferred according to the degree of geologic assurance of the estimate:

Measured - Resources are computed from dimensions revealed in outcrops, trenches, mine workings, and drill holes. The points of observation and measurement are so closely spaced and the thickness and extent of coals are so well defined that the tonnage is judged to be accurate within 20 percent of true tonnage. Although the spacing of the points of observation necessary to demonstrate continuity of the coal differs from region to region according to the character of the coal beds, the points of observation are no greater than 1/2 mile (0.8 km) apart. Measured coal is projected to extend as a 1/4 mile (0.4 km) wide belt from the outcrop or points of observation or measurement.

Table D-1.--USGS sample number, hole number, location and depth interval for 17 coal and shale samples from the Kimbeto study site, San Juan County, N. Mex.

[All samples are from the Fruitland Formation of Cretaceous age. One foot = 0.305 meters]

USGS sample number	Hole number	Location	Depth interval, in feet	Description
D194012	1K	SE¼NW¼ sec. 18 T. 22 N., R. 10 W.	25.8- 33.8	coal
D194013	-do-	----------do----------	48.4- 50.9	shale, coaly
D194014	-do-	----------do----------	62.2- 65.7	Do.
D194015	-do-	----------do----------	106.0-108.6	coal, shaley
D194016	-do-	----------do----------	116.1-125.5	coal
D194017	3K	SE¼SW¼ sec. 7 T. 22 N., R. 10 W.	78.6- 80.1	Do.
D194018	-do-	----------do----------	82.5- 93.3	Do.
D194019	-do-	----------do----------	134.0-141.0	coal, shaley
D194020	-do-	----------do----------	161.8-169.8	Do.
D194021	-do-	----------do----------	191.2-196.2	Do.
D194022	-do-	----------do----------	206.3-218.4	Do.
D194023	6K	NW¼SW¼ sec. 4 T. 22 N., R. 10 W.	214.0-232.9	Do.
D194024	-do-	----------do----------	245.6-246.2	Do.
D194025	-do-	----------do----------	255.0-258.5	Do.
D194026	-do-	----------do----------	271.1-284.0	Do.
D194027	-do-	----------do----------	318.3-322.1	shale, coaly
D194028	8K	SE¼SW¼ sec. 10 T. 22 N., R. 10 W.	192.8-228.5	coal, shaley

Table D-2.--Proximate and ultimate analyses, heat-of-combustion, forms-of-sulfur, free-swelling-index, and ash-fusion-temperature determination for 17 coal and shale samples from the Fruitland Formation, Kimbeto EMRIA study site, San Juan County, N. Mex.

[All analyses except heat of combustion, free swelling index and ash-fusion temperature in percent. For each sample number, the analyses are reported three ways: first, as-received, second, moisture free, and third, moisture and ash free. All analyses by Coal Analysis Section, U.S. Department of Energy, Pittsburgh, Pa. °C = (°F-32) 5/9; Kcal/kg = 0.556 Btu/lb.]

Sample number	Proximate Analysis				Ultimate Analysis					Heat of Combustion	
	Moisture	Volatile matter	Fixed carbon	Ash	Hydrogen	Carbon	Nitrogen	Oxygen	Sulfur	Kcal/kg	Btu/lb
D194012	15.0	31.7	37.4	15.9	5.6	52.4	1.1	24.4	0.6	5,140	9,250
	---	37.3	44.0	18.7	4.6	61.6	1.3	13.0	.7	6,050	10,880
	---	45.9	54.1	---	5.7	75.8	1.6	16.0	.9	7,440	13,390
D194013	15.4	13.1	4.3	67.2	2.9	11.1	.3	18.3	.3	1,030	1,850
	---	15.5	5.1	79.4	1.4	13.1	.4	5.5	.4	1,220	2,190
	---	75.3	24.7	---	6.8	63.8	1.7	26.5	1.7	5,920	10,660
D194014	13.5	21.5	19.9	45.1	4.0	30.2	.6	19.7	.4	2,900	5,220
	---	24.9	23.0	52.1	2.9	34.9	.7	8.9	.5	3,360	6,040
	---	51.9	48.1	---	6.0	72.9	1.4	18.6	1.0	7,010	12,620
D194015	14.1	27.7	30.3	27.9	5.4	43.0	.9	22.3	.6	4,200	7,570
	---	32.2	35.3	32.5	4.5	50.1	1.0	11.4	.7	4,890	8,810
	---	47.8	52.2	---	6.6	74.1	1.6	16.8	1.0	7,250	13,050
D194016	15.4	32.4	41.2	11.0	5.9	57.2	1.2	24.1	.6	5,540	9,970
	---	38.3	48.7	13.0	5.0	67.6	1.4	12.3	.7	6,550	11,780
	---	44.0	56.0	---	5.7	77.7	1.6	14.1	.8	7,520	13,540
D194017	14.9	34.5	41.3	9.3	6.2	59.4	1.2	23.3	.6	5,780	10,410
	---	40.5	48.5	10.9	5.3	69.8	1.4	11.8	.7	6,790	12,230
	---	45.5	54.5	---	6.0	78.4	1.6	13.3	.8	7,630	13,730
D194018	12.7	33.5	35.3	18.5	5.4	52.3	1.0	22.2	.6	5,110	9,200
	---	38.4	40.4	21.2	4.6	59.9	1.1	12.5	.7	5,850	10,540
	---	48.7	51.3	---	5.8	76.0	1.5	15.9	.9	7,430	13,370
D194019	13.6	28.3	28.8	29.3	4.9	42.5	.9	21.9	.7	4,210	7,570
	---	32.8	33.3	33.9	3.9	49.2	1.0	11.4	.8	4,870	8,770
	---	49.6	50.4	---	5.9	74.4	1.6	17.2	1.2	7,370	13,260
D194020	16.8	27.0	32.0	24.2	5.1	44.0	.9	25.4	.4	4,340	7,820
	---	32.5	38.5	29.1	3.9	52.9	1.1	12.6	.5	5,220	9,390
	---	45.8	54.2	---	5.5	74.6	1.5	17.7	.7	7,360	13,250
D194021	15.5	25.7	25.6	33.2	4.8	37.5	.8	23.2	.5	3,680	6,620
	---	30.4	30.3	39.3	3.6	44.4	.9	11.2	.6	4,350	7,830
	---	50.1	49.9	---	6.0	73.1	1.1	18.4	1.0	7,160	12,900
D194022	15.4	26.3	33.1	25.2	5.1	45.0	1.0	23.4	.4	4,380	7,880
	---	31.1	39.1	29.8	4.0	53.2	1.2	11.5	.5	5,180	9,320
	---	44.3	55.7	---	5.7	75.8	1.7	16.3	.7	7,370	13,270
D194023	13.6	32.1	32.2	22.1	5.3	48.5	.9	22.7	.5	4,760	8,570
	---	37.2	37.3	25.6	4.4	56.1	1.0	12.3	.6	5,510	9,920
	---	49.9	50.1	---	5.9	75.4	1.4	16.5	.8	7,410	13,330

Table D-2.--Proximate and ultimate analyses, heat-of-combustion, forms-of-sulfur, free-swelling-index, and ash-fusion-temperature determination for 17 coal and shale samples from the Fruitland Formation, Kimbeto EMRIA study site, San Juan County, N. Mex.--Continued

Sample number	Air-dried loss	Forms of sulfur			Free swelling	Ash fusion temperature °C		
		Sulfate	Pyritic	Organic		Initial deformation	Softening	Fluid
D194012	9.7	0.04	0.21	0.34	0.0	1,435	1,490	1,540
	---	.05	.25	.40				
	---	.06	.30	.49				
D194013	11.1	.04	.20	.03	.0	1,435	1,490	1,540
	---	.05	.24	.04				
	---	.23	1.15	.17				
D194014	8.2	.01	.18	.25	.0	1,540	1,540	1,540
	---	.01	.21	.29				
	---	.02	.43	.60				
D194015	9.2	.01	.10	.46	.0	1,540	1,540	1,540
	---	.01	.12	.54				
	---	.02	.17	.79				
D194016	9.5	.02	.23	.37	.0	1,400	1,455	1,515
	---	.02	.27	.44				
	---	.03	.31	.50				
D194017	8.5	.04	.05	.55	.0	1,325	1,375	1,430
	---	.05	.06	.65				
	---	.05	.07	.73				
D194018	7.7	.03	.07	.53	.0	1,540	1,540	1,540
	---	.03	.08	.61				
	---	.04	.10	.77				
D194019	8.4	.05	.16	.46	.0	1,540	1,540	1,540
	---	.06	.19	.53				
	---	.09	.28	.81				
D194020	11.6	.02	.04	.33	.0	1,515	1,540	1,540
	---	.02	.05	.40				
	---	.03	.07	.56				
D194021	10.0	.02	.13	.32	.0	1,540	1,540	1,540
	---	.02	.15	.38				
	---	.04	.25	.62				
D194022	10.1	.03	.10	.23	.0	1,540	1,540	1,540
	---	.04	.12	.27				
	---	.05	.17	.39				
D194023	8.7	.03	.11	.34	.0	1,540	1,540	1,540
	---	.03	.13	.39				
	---	.05	.17	.53				

Table D-2.--Proximate and ultimate analyses, heat-of-combustion, forms-of-sulfur, free-swelling-index, and ash-fusion-temperature determination for 17 coal and shale samples from the Fruitland Formation, Kimbeto EMRIA study site, San Juan County, N. Mex.--Continued

Sample number	Proximate Analysis				Ultimate Analysis					Heat of Combustion	
	Moisture	Volatile matter	Fixed carbon	Ash	Hydrogen	Carbon	Nitrogen	Oxygen	Sulfur	Kcal/kg	Btu/lb
D194024	14.3	27.6	29.6	28.5	5.0	42.6	0.9	22.4	0.5	4,220	7,600
	---	32.2	34.5	33.3	4.0	49.7	1.1	11.3	.6	4,920	8,860
	---	48.3	51.7	---	6.0	74.5	1.6	16.9	.9	7,380	13,280
D194025	14.1	27.4	25.8	32.7	4.9	39.6	.8	21.4	.5	3,860	6,940
	---	31.9	30.0	38.1	3.9	46.1	.9	10.3	.6	4,490	8,080
	---	51.5	48.5	---	6.3	74.4	1.5	16.7	.9	7,250	13,050
D194026	14.7	28.0	28.7	28.6	5.2	41.9	.9	23.0	.4	4,120	7,420
	---	32.8	33.6	33.5	4.2	49.1	1.1	11.6	.5	4,830	8,700
	---	49.4	50.6	---	6.3	73.9	1.6	17.5	.7	7,270	13,090
D194027	11.7	12.5	8.3	67.5	2.8	12.7	.3	15.1	1.6	1,210	2,170
	---	14.2	9.4	76.4	1.7	14.4	.3	5.3	1.8	1,370	2,460
	---	60.1	39.9	---	7.2	61.1	1.4	22.6	7.7	5,810	10,450
D194028	13.9	32.3	32.0	21.8	5.4	48.8	.9	22.5	.5	4,750	8,560
	---	37.5	37.2	25.3	4.5	56.7	1.0	11.8	.6	5,520	9,940
	---	50.2	49.8	---	6.0	75.9	1.4	15.8	.8	7,390	13,310

Sample number	Forms of sulfur				Free swelling	Ash fusion temperature C°		
	Air-dried loss	Sulfate	Pyritic	Organic		Initial deformation	Softening	Fluid
D194024	9.3	0.03	0.11	0.37	0.0	1,515	1,540	1,540
	---	.04	.13	.43				
	---	.05	.19	.65				
D194025	8.8	.02	.11	.36	.0	1,540	1,540	1,540
	---	.02	.13	.42				
	---	.04	.21	.68				
D194026	9.9	.02	.11	.31	.0	1,540	1,540	1,540
	---	.02	.13	.36				
	---	.04	.19	.55				
D194027	8.2	.41	.82	.33	.0	1,290	1,345	1,400
	---	.46	.93	.37				
	---	1.97	3.94	1.59				
D194028	8.8	.01	.12	.36	.0	1,540	1,540	1,540
	---	.01	.14	.42				
	---	.02	.19	.56				

Table D-3.--Summary of estimated identified coal resources of the Kimbeto EMRIA Study Site

[In thousands of tons]

	Overburden thickness (feet)		
	0-200	200-400	Total
Coal beds 2½ to 5 feet thick			
Measured resources	5,177	2,291	7,468
Indicated resources	26,915	9,091	36,006
Inferred resources	14,415	1,966	16,381
Total	46,507	13,348	59,855
Coal beds 5 to 10 feet thick			
Measured resources	13,130	2,915	16,045
Indicated resources	75,446	13,873	94,319
Inferred resources	82,134	9,092	91,226
Total	170,710	30,880	201,590
Coal beds more than 10 feet thick			
Measured resources	25,120	20,452	45,572
Indicated resources	135,517	103,236	238,753
Inferred resources	42,187	28,009	70,196
Total	202,824	151,697	354,521
Total identified resources	420,041	195,925	615,966

Indicated - Resources are computed partly from specific measurements and partly from projections of visible data for a reasonable distance on the basis of geologic evidence. The points of observation are 1/2 (0.8 km) to 1 1/2 miles (2.4 km) apart. Indicated coal is projected to extend as a 1/2 mile (0.8 km) wide belt that lies more than 1/4 mile (0.4 km) from the outcrop or points of observation or measurement.

Inferred - Quantitative estimates are based largely on broad knowledge of the geologic character of the bed or region, because few measurements of bed thickness are available. The estimates are based primarily on an assumed continuation from measured and indicated coal for which geologic evidence exists. The points of observation are 1 1/2 (2.4 km) to 6 miles (9.6 km) apart. Inferred coal is projected to extend as a 2 1/4-mile (3.6-km) wide belt that lies more than 3/4 mile (1.2 km) from the outcrop or points of observation or measurement.

All of the estimated resources in beds thicker than 5 feet (1.5 m) and at depths of 1000 feet (305 m) or less fall into a category called reserve base, which is defined as that portion of the identified coal resource from which reserves are calculated. Reserves are that portion of the identified coal resource that can be economically mined at the time of determination. The reserve is derived by applying a recovery factor to that component of the identified coal resource designated as the reserve base. On a national basis the estimated recovery factor for the total reserve base is 50 percent. More precise recovery factors can be computed by determining the total coal in place and the total coal recoverable in any specific locale.

Characteristics used in resource evaluation

The coal characteristics that are commonly used in classifying coal resources are: rank, grade, and weight of the coal; thickness of the coal beds; and thickness of the overburden. Rank and grade have been discussed previously.

Weight

The weight of the coal ranges considerably with differences in rank and ash content. In areas such as the Kimbeto EMRIA study site, where true specific gravities of the coal have not been determined, an average specific gravity value based on many determinations in other areas is used to express the weight of the coal for resource calculations. The average weight of subbituminous coal is taken as 1,800 tons per acre-foot--a specific gravity of 1.30.

Thickness of beds

Because of the important relationship of coal-bed thickness to utilization potential, most coal resource estimates prepared by the U.S. Geological Survey are tabulated according to three thickness categories. Because the coal evaluated in this report is so close to the bituminous-subbituminous division of rank, the thickness categories used are thin (2.5 to 5 feet, 0.75 to 1.5 m); intermediate (5 to 10 feet, 1.5 to 3 m); and thick (more than 10 feet, 3 m). About 9.7 percent of the estimated resources of the study area is in the thin category, about 32.7 percent is in the

intermediate category, and about 57.6 percent is in the thick category. By way of comparison, Averitt (1975, Figure 5 and page 37) showed the distribution of the estimated resources of 21 states as 42 percent in the thin category, 25 percent in the intermediate category, and 33 percent in the thick category.

Thickness of overburden

All of the estimated coal resources in the Kimbeto EMRIA site are overlain by 400 feet (120 m) or less of overburden.

Summary of Resources

Total estimated identified original resources in the Kimbeto EMRIA site are 615,966,000 tons (558,681,000 metric tons). The coal-bed thickness class of 2.5-5 feet contains 59,855,000 tons (54,288,000 metric tons). The coal-bed thickness class of 5-10 feet contains 201,590,000 tons (182,882,000 metric tons) of the estimated resources. The coal-bed thickness class of greater than 10 feet contains 354,521,000 tons (321,621,000 metric tons) of the estimated resources.

The estimated resources presented in this report are original resources; that is, resources in the ground before the beginning of mining operations.

Chemical analyses of coal and coaly shale in the Fruitland Formation Kimbeto study site

Fourteen samples of coal and three samples of coaly shale were collected by the U.S. Geological Survey from four core holes in the Kimbeto study area. These samples are briefly described in table D-1. Proximate and ultimate analyses, heat-of-combustion, air-dried-loss, forms-of-sulfur, and ash-fusion-temperature determinations for all 17 samples are listed in table D-2. These analyses were provided by the Coal Analysis Section of the U.S. Department of Energy, Pittsburgh, Pa. Analyses for ash content, and 32 major and minor oxides and trace elements in the laboratory ash (table 0-3), and analyses of nine trace elements in whole-coal and shale (table 0-4) for the samples were provided by the Analytical Laboratories of the U.S. Geological Survey in Denver, Colo. Analytical procedures used by the U.S. Geological Survey are described in Swanson and Huffman (1976). Table 0-5 contains the data listed in table 0-3 converted to a whole-coal and shale basis and includes the whole-coal and shale analyses listed in table 0-4. Twenty-five additional elements were looked for but not found in amounts greater than their lower limit of detection (table 0-6).

Discussion

The apparent ranks of the 14 coal samples were calculated using the data in table D-2 and the formulae in ASTM designation D-388-77 (American Society for Testing of Materials, 1977). The apparent rank ranges from subbituminous B (six samples) to subbituminous A coal (8 samples). When calculated on a moist-mineral-matter-free basis, the heats of combustion for the 14 coal samples listed in table D-2 range from 5,805 to 6,450 Kcal/kg (10,440 to 11,600 Btu/lb) and have a mean of 6,165 Kcal/kg (11,090 Btu/lb).

A statistical comparison (students t-test, 95-percent confidence level) of the 14 U.S. Department of Energy analyses of coal from the Fruitland Formation of the Kimbeto site with 86 other coal analyses from the Rocky Mountain province shows that coal from the Kimbeto study site has a significantly higher ash content and significantly lower contents of volatile matter, fixed carbon, carbon, and a significantly lower heat of combustion. Contents of moisture, hydrogen, nitrogen, oxygen, total sulfur, and sulfate, pyritic and organic sulfur, are similar for both sample sets.

A statistical comparison of the mean contents of coal ash and contents in ash of nine major and minor oxides from the 14 Kimbeto study site samples with 79 other San Juan River region coal samples, shows that coal from the Kimbeto study area has significantly higher ash content and SiO_2 content in ash and significantly lower in CaO, MgO, and Fe_2O_3 contents in ash. The contents of Al_2O_3, Na_2O, K_2O, TiO_2, and SO_3 in ash are not significantly different. When compared at the 99-percent confidence level, the ash content and Fe_2O_3 content in ash are similar for both sample sets.

A statistical comparison of the mean contents of 35 elements in the 14 Fruitland Formation coal samples from the Kimbeto study site with 79 other San Juan River region coal samples shows that coal from the Kimbeto study area has significantly higher contents of Si, Al, Na, Ti, Be, Co, Cr, Ga, Nb, Ni, Sc, U, Y, and Zr and significantly lower contnts of Ca, Ba, Sb, Sr, and Yb. The contents of Mg, K, Fe, As, B, Cu, F, Hg, Li, Mn, Mo, Pb, Se, Th, V, and Zn are not significantly different. When compared at the 99-percent confidence level the contents of Al and Co are similar for both sample sets. When compared at the 99 percent confidence level Al and Co contents are similar for both sets.

Differences in the oxide composition of coal ashes and the element contents of coal result from differences in the total and relative amounts of the various minerals, the elemental composition of these minerals, and the total and relative amounts of any organically bound elements. The chemical form and distribution of a given element is dependent on the geologic history of the coal bed. A partial listing of the geologic factors that may influence element distributions would include chemical composition of original plants; amounts and compositions of the various detrital, diagenetic, and epigenetic minerals; chemical characteristics of the ground waters that come in contact with the bed; temperatures and pressures during burial; and extent of weathering. No evaluation of these factors has been made for the coal beds in the Kimbeto study site.

SECTION E

OVERBURDEN GEOCHEMISTRY

SECTION E
OVERBURDEN GEOCHEMISTRY

Samples from the column of overburden rock at Kimbeto were analyzed for bulk* chemical composition. The purpose was to find out whether any of the rock material had unusually high contents of chemical elements of potential environmental concern, especially in comparison to rocks that overlie coal in other Western energy regions.

A second goal was to find out whether benign rock material could be distinguished in some clear and simple way from potentially hazardous material without expensive analysis.

In order to assess the value of Kimbeto rocks for use in reclamation after mining, it is useful to know how their detailed chemistry compares with that of other overburden rocks that have been investigated, of both similar and different ages, and from both nearby and distant sites.

Sampling Scheme

Samples were taken from hole numbers 5 and 10, which are about 1 mi (0.6 km) apart. The holes were sampled to depths of 333 ft. (109 m) and 436 ft. (143 m), respectively. Choosing a random depth within the top 10 ft. (3 m) as a starting point, a 6 in. (0.16 m) segment of the "nx" core (about 2 in. or 5 cm in diameter) was taken every 10 ft. Every fifth sample, an extra sample was taken, separated by a 6 in. gap. This was to aid in determining the relationship between chemical variability and spatial separation of samples.

* The term "bulk" may also be expressed as "whole-rock."

Classification of Samples into Rock Types

Samples were classified by lithic type, as identified by quick, simple tests and by appearance in hand specimens, to determine whether the different rock types had distinctive chemistry. The theory being, it might be possible to predict the chemistry from hand specimen observation in future work, thereby avoiding considerable delay and analytical expense.

The samples were classified into the following groups:

(1) Sandstone (grain size greater than approximately 0.2mm);
(2) Siltstone (grains visible by hand lens, 0.2mm or smaller); and
(3) Claystone (shale and other very fine grained rocks).

Analytical

The samples were analyzed for total concentrations of a suite of major, minor and trace elements, by spectrographic techniques (emission and X-ray fluorescence). Results of "availability" (chemical leach) determinations will be available later. A complete tabulation of determinations of all chemical elements detected, for all samples, is presented as an appendix.

Chemical Distinctiveness of Rock Types

Overburden rocks at Kimbeto show a general relationship between chemistry and rock type. Coarse- and fine-grained rocks have characteristic chemical properties, but there is considerable overlap in chemical composition. The data are presented in Table P-2, not only for the Kimbeto site but also for the nearby experimental reclamation site 35 miles east southeast in northeastern McKinley County called Ojo Encino, for a broader sampling of overburden rocks of similar age (Cretaceous) throughout the Western Energy Regions, and for soils and mine spoils of the San Juan Basin.

Table P-2 presents selected elements that are of the greatest geological and environmental interest. With few exceptions, the sandstones have the lowest, the siltstone (single sample) has intermediate and claystones have the highest concentrations of trace elements of potential environmental concern (boron, cobalt, chromium, copper, molybdenum, lead, vanadium, and zinc).

The rocks from the Kimbeto and Ojo Encino sites in the San Juan Basin have less chemical difference between rock type than rocks from other sites underlain by rocks of Cretaceous age. The chemical data suggest that this is so because the sandstones in the San Juan Basin are arkosic (contain grains of feldspar rather than of quartz) and because there is an appreciable amount of clay in rocks of all types. At some other locations sandstones are much more purely quartz, and the clay minerals are concentrated to a greater extent in the claystones (shales). Quartz is a mineral that is nearly barren of trace elements, feldspar contains modest amounts of many trace elements, and clay minerals contain larger amounts.

Chemistry of Kimbeto (and Ojo Encino) Rocks Compared to Other Overburden Rocks of the Same and Different Ages

In order to assess the value of Kimbeto rocks for use in reclamation after mining, it is useful to know how their detailed chemistry compares with that of other overburden rocks that have been investigated, of both similar and different ages (Hinkley and others, 1980; Hinkley and others, 1978) and from both nearby and distant sites. In this respect, each of the chemical parameters in Table P-2 is discussed below.

The basis of the discussion are the data in Table P-2 where only average concentration values are given. For all chemical elements except SiO_2, the geometric mean rather than the arithmetic mean is shown because it tends to minimize the effect of the (very high) values which may appear in the data set, and tends to increase the likelihood that the average value will fall in the range of the more common central values that are really most typical of the set of data.

To give an idea of the dispersion (variance) of the data, a table of geometric deviations is presented (Table P-3). The geometric deviations in table P-3 provide information about how closely the whole body of data is grouped about the average, or how broadly dispersed it is, with extreme values far from the average. The geometric means (GM) and deviations (GD) are used in the following way to assess the spread of the data: about two thirds of the values fall between a lower limit of GM/GD and an upper limit of GM·GD; about 95 percent of the values fall in the broader range defined by $GM/(GD)^2$ and $GM \cdot (GD)^2$. For example, zinc in claystone from "Other sites with Cretaceous overburden" (tables P-2 and P-3) has a geometric mean of 105 ppm and a geometric deviation of 1.4; 95 percent of samples of such material should have values between $105/(1.4)^2 = 54$ ppm and $105 \times (1.4)^2 = 206$ ppm.

SiO_2--Kimbeto rocks fall into the middle part of the total range in SiO_2 concentration seen in the the larger group of sites that have the same age rock (Cretaceous rock) overlying coal. This indicates that the New Mexico rocks are less pure as lithic types--there is more clay and feldspar in the sandstones, and more sand in the claystones than is common elsewhere.

Al_2O_3-There is more aluminum in the Kimbeto and Ojo Encino rocks than in other Cretaceous overburden, indicating, in complement to the SiO_2 data, that there are larger amounts of clay and feldspar in the sandstone and siltstone.

CaO---Sandstone and siltstone at Kimbeto and Ojo Encino are high in calcium relative to other Cretaceous overburden, whereas the claystones are low in calcium relative to the other rocks. This is probably because of the presence of Ca-rich feldspars in the sandstone and siltstone.

Na_2O--All three rock types are several times higher in sodium at Kimbeto and Ojo Encino than in other Cretaceous overburden. New Mexico concentrations are closer to those for corresponding rock types in overburden of Tertiary Fort Union Formation material but the New Mexico rocks are higher by as much as a factor of two.

K_2O---Kimbeto and Ojo Encino rocks are slightly higher in potassium than other Cretaceous overburden.

B-----Kimbeto and Ojo Encino rocks are similar to other Cretaceous overburden rocks in boron concentration. However, some suites of Tertiary overburden samples have boron concentrations 2 to 5 times higher in both sandstone and claystone.

Co----Kimbeto and Ojo Encino rocks, especially sandstones, are higher in cobalt concentration than other Cretaceous overburden rocks, but are about comparable to Tertiary rocks.

Cr----Kimbeto and Ojo Encino rocks are comparable in chromium content to other Cretaceous overburden sites, with New Mexico sandstones slightly higher, siltstone and claystones slightly lower. Tertiary overburden rocks may be 2-5 fold higher.

Cu----Kimbeto and Ojo Encino rocks are higher in copper than other Cretaceous overburden rocks, but comparable to Tertiary overburden rocks.

Mo----Kimbeto and Ojo Encino rocks are comparable to or slightly higher than other Cretaceous rocks in molybdenum concentration, but they apparently have only about half (or less) as much as Tertiary overburden rocks. In areas of Tertiary overburden, molybdenum toxicity is widely regarded as a potential problem in mine spoil reclamation (Erdman and others, 1978).

Pb----Lead concentrations are slightly higher in Kimbeto and Ojo Encino rocks than in other Cretaceous overburden. They are comparable to lead values in Tertiary rocks, but in Tertiary rocks there is much greater difference between sandstone (high) and claystone (low) than in Cretaceous rocks.

V-----Vanadium concentrations in Kimbeto and Ojo Encino rocks are similar to those in Cretaceous overburden rocks from other areas. They are similar to concentrations in Tertiary overburden rocks.

Zn----Zinc concentrations in Kimbeto and Ojo Encino rocks are similar to those in Cretaceous rocks from other areas, but in the other areas there is a greater contrast in concentrations between sandstone (low) and claystone (high) than is seen at the New Mexico sites. Concentrations are similar to those in Tertiary overburden rocks.

Similarity of Kimbeto Overburden Rocks to Natural San Juan Basin Soils

Kimbeto overburden rocks are similar in bulk composition to natural soils of the San Juan basin. The data are summarized in Table P-2. The rocks are very similar to the soils with respect to sodium, the element of most concern in reclamation considerations. There are, to varying but moderate degrees, higher concentrations of the following elements in the Kimbeto overburden than in the soils: aluminum, cobalt, copper, lead, vanadium, and zinc. The higher concentrations of copper and zinc in the rocks might be favorable should they ever be used as soil replacement material. Except for very unusual geochemical and climatic settings, the elements cobalt, lead, and vanadium are seldom present in sufficiently high concentrations to be toxic hazards.

The bulk chemistry of Kimbeto overburden rock is generally favorable with respect to post-mining reclamation of the study area. However, for determining the immediate suitability of the rock as a replacement for the soils of the study area, other factors, such as texture, water-holding capacity, permeability, salinity, sodicity, and weatherability, must also be considered. These other factors were the basis for the suitability determinations discussed in section F of this report.

Relative Abundance of Rock Types

At Kimbeto the ratios of sandstone-to-siltstone-to-claystone in drill cores sampled were about 2 : 1/4 : 1 (46 samples); at Ojo Encino they were about 6 : 1/4 : 1 (31 samples), and at the other four Cretaceous sites from other states, they were about $1\frac{1}{3}$: 1/2 : 1 (112 samples). In New Mexico, sandstone was more dominant over claystone (shale) than at other Cretaceous sites, although there is a big difference between the two San Juan Basin sites (3 fold more sand at Ojo Encino). Siltstone is not very abundant anywhere.

SECTION F

LAND AND OVERBURDEN

SECTION F
LAND AND OVERBURDEN

Major Land Categories

There are four major land categories encompassing the landforms and soil bodies of the study area. These are: mesas (about 25 percent of the study area), valleys (25 percent), badlands (41 percent), and miscellaneous (9 percent). Figure F-1 shows the approximate location and distribution of the categories. (Figures Q-1 through Q-24 show the categories in detail and table Q-1 lists the acreage in the major land categories by range, township, and section.)

Mesas

This category is dominated by mesas but also includes elevated benches, sandy ridges, and long side slopes. The topography is nearly level to gently sloping, slightly undulating, or, infrequently, very gently rolling. The soils are formed mainly from thick alluvial deposits on ancient stream terraces or alluvial fans. Geologic erosion has worn away adjacent areas of the original landscape, leaving lands of this category elevated. Some of the best vegetation of the study site is supported by lands of this catagory.

Soil above bedrock is usually 60 inches or more deep. Colors of the surface soil are pale brown, light yellowish brown, brown, or light brownish gray. Textures generally range from fine sand to loam. Structure is usually single grain, granular, or structureless. Subsoil textures and colors range from fine sand to clay loam and light yellowish-brown through light brownish-gray. Structure is mainly single grain, fine granular, or massive.

Permeability is moderatly rapid to rapid with relatively low water holding capacity. Soils are generally nonsaline and nonsodic. No harmful accumulations of other chemicals were detected; however, accumulations of calcium carbonate were found in the subsoil of more pronounced mesas.

With the exception of some nutrient deficient soils, most of the soils in this land category are highly suitable as a source of planting media (see Land Suitability in this section for definition of suitable and unsuitable planting media and specifications, table F-1.)

Soil profiles 38, 47, 78, 82, and 84 are representative of this category (see figures Q-25 through Q-35 for a description of these profiles). The dominant soil series are Doak, Shiprock, Sheppard, and Nageesi. (See Soil Inventory in Section Q for more information on soil series at the study area.)

Valleys

Valley lands at the study area have a wide range of characteristics. Depth to bedrock varies from zero to at least 10 feet. Much of the valley land with

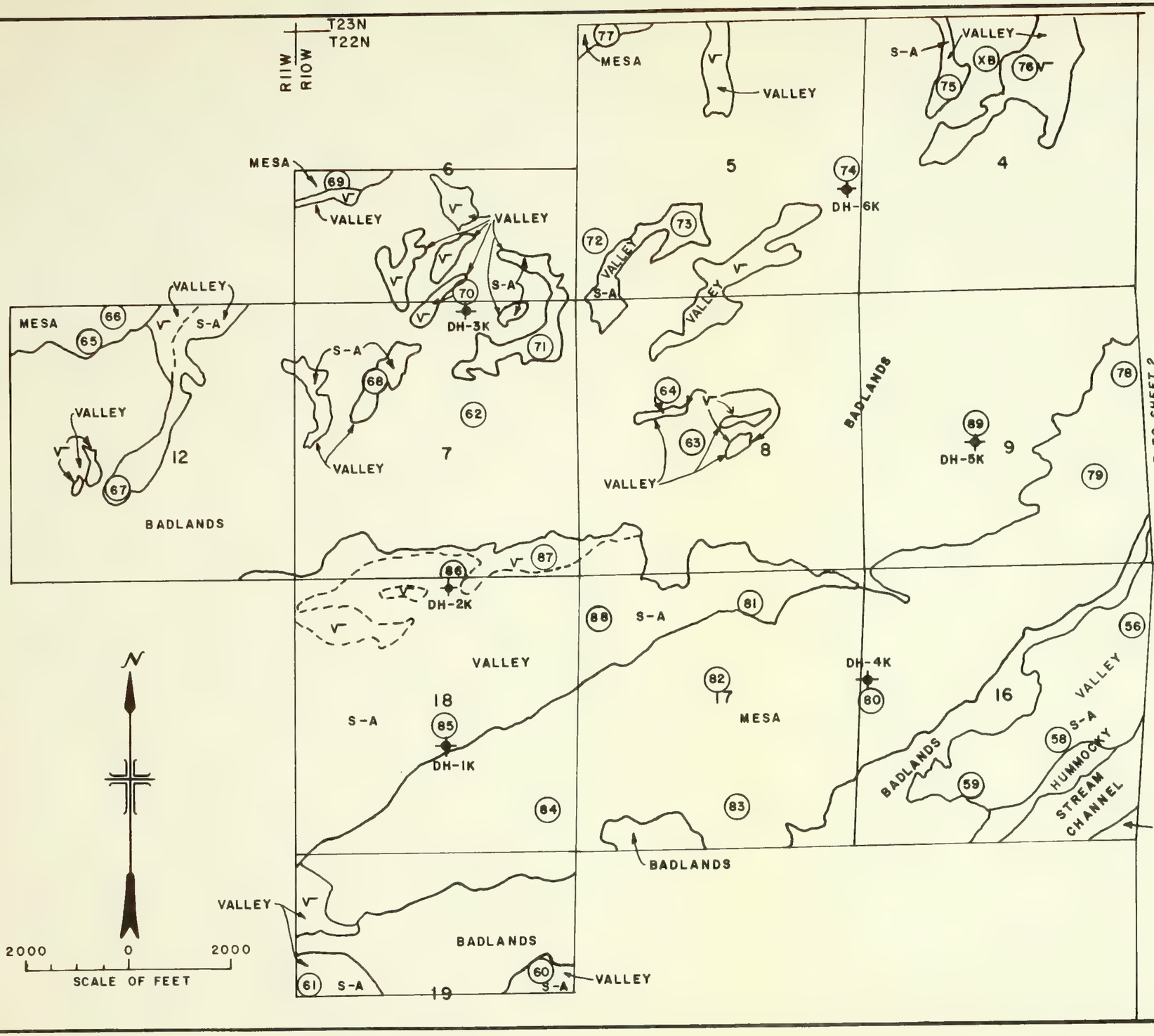
Table F-1
Land Suitability Specifications
for
Lands to Be Used as a Source of Topsoil for
Reclamation of Surface-Mined Areas 1/
BLM-BR Cooperative EMRIA Program
Kimbeto Study Area, New Mexico

Soils 2/	Land Class 1	Land Class 2
Texture or rock type	lfs - cl	fs - c
Available water-holding capacity	1.25 in/ft	0.75 in/ft
Permeability (Internal drainage)	Adequate to provide a well-drained and aerated root zone and an infiltration rate adequate to prevent serious erosion.	Restricted to the extent that internal drainage may limit choice of vegetation and a limited infiltration rate which will require special practices to control erosion.
Salinity (at equilibrium)	$\leq$ 4 millimhos	$\leq$ 12 millimhos
Sodicity (at equilibrium)	$\leq$ 10 ESP - may be higher if permeability meets limits for class 1.	$\leq$ 15 ESP - may be higher if permeability meets limits for class 2.
Erodibility	May be subject to slight erosion.	May be susceptible to moderate to severe erosion but can be controlled with proper management.
Weatherability 3/	Will break down readily soon after exposure to weather.	May require extended period to break down into optimum particle size distribution for planting media, but can be used in less desirable state in reasonable time period.
Depth	A minimum of 36 inches of usable and strippable material.	A minimum of 6 inches of usable and strippable material. 4/
Topography 5/		
Slope	$\leq$ 20 percent	$\leq$ 35 percent
Surface rocks	Not a factor on study area.	
Bedrock outcrops	Will not affect stripping or quantity of suitable material appreciably.	Numerous enough to reduce quantity of suitable material appreciably and make stripping expensive.
Drainage	Because of land disturbance by surface-mining, present drainage conditions, except the permeability of the material, are not a factor in the classification. Permeability limits are covered under Soils.	
Class 6	All areas are not meeting the minimum requirements for class 2. These lands, in their present state, will not provide adequate planting media for reclamation purposes.	

1/ Specifications are based on rainfed conditions or a minimum or irrigation for starting plantings and maintaining them for 1-2 years.
2/ The limitations under Soils are applicable to the evaluation of both soil and the remaining overburden material between the coal and soil.
3/ Weatherability is applicable only to bedrock or consolidated material.
4/ Six inches is considered as the minimum strippable depth.
5/ Topographic factors considered are related primarily to stripping conditions.

Photo F-1. Looking south near profile 80 at Class 1 mesa land. (See figure F-1 for profile locations.)

Photo F-2. Edge view of mesa land (background) near profile 6, with badlands in foreground.



EXPLANATION:

MAJOR LAND CATEGORY	ACRES
MESA	3,052
BADLANDS	5,026
VALLEY	
V-SANDY	1,051
S-A-SALINE-SODIC	1,974
MISCELLANEOUS	
STREAM CHANNEL	294
HUMMOCKY	666
ACTIVE DUNES	97
TOTAL (SHEETS 1 & 2)	12,160

(10) PROFILE LOCATIONS

---- SEPARATES VALLEY SUB-CATEGORIES

—— SEPARATES LAND CATEGORIES

✦ DRILL HOLE LOCATIONS

ALWAYS THINK SAFETY

UNITED STATES
DEPARTMENT OF THE INTERIOR
WATER AND POWER RESOURCES SERVICE

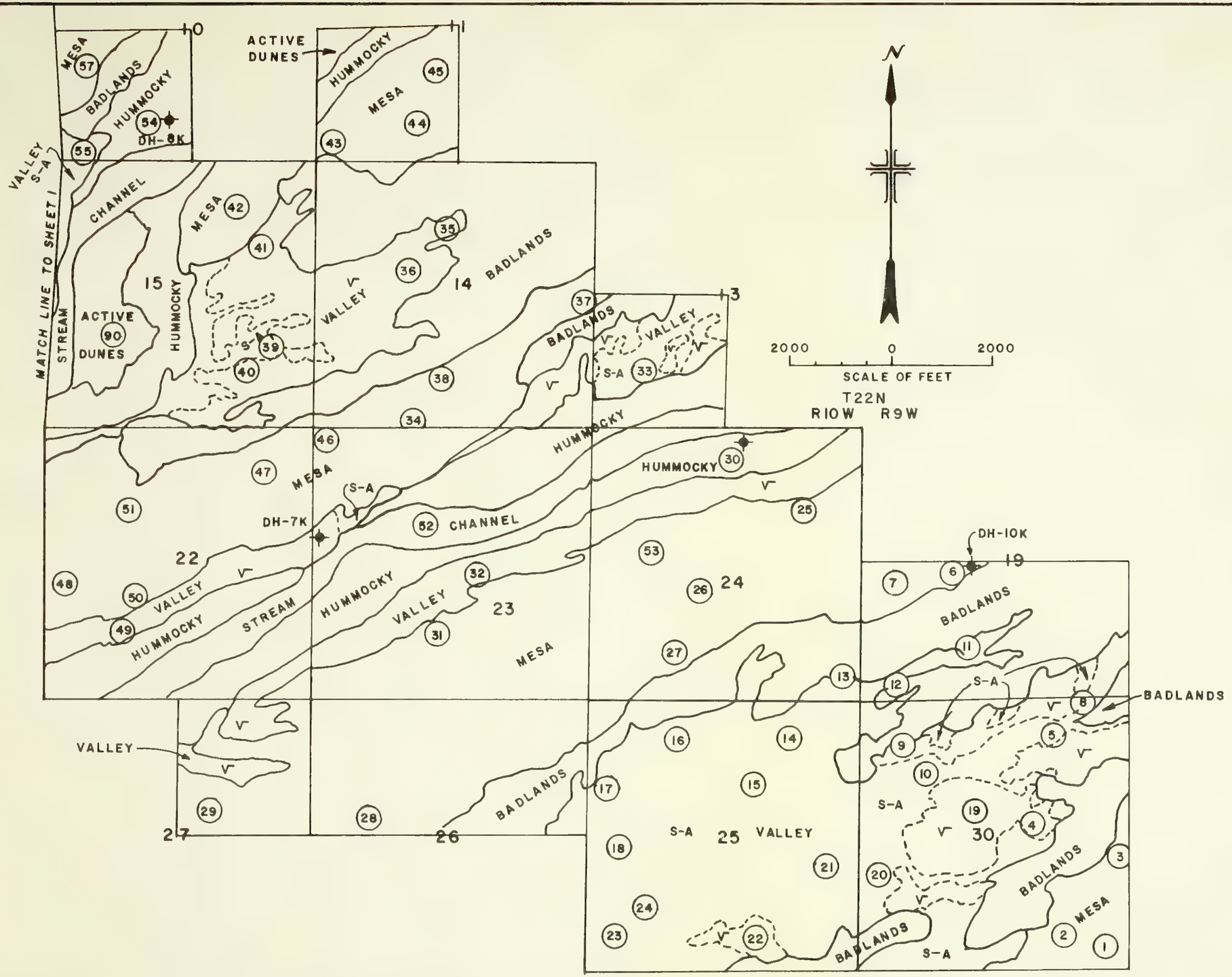
EMRIA REPORT NO. 17-77
KIMBETO STUDY AREA - NEW MEXICO

MAJOR LAND CATEGORIES

DESIGNED _____ SUBMITTED _____
DRAWN _____ RECOMMENDED _____
CHECKED _____ APPROVED _____

AMARILLO, TEX. JAN. 1978 SHEET 1 OF 2

Figure F-1



EXPLANATION:

MAJOR LAND CATEGORY	ACRES
MESA	3,052
BADLANDS	5,026
VALLEY	
V-SANDY	1,051
S-A-SALINE-SODIC	1,974
MISCELLANEOUS	
STREAM CHANNEL	294
HUMMOCKY	666
ACTIVE DUNES	97
TOTAL (SHEETS 1 & 2)	12,160

(10) PROFILE LOCATIONS

---- SEPARATES VALLEY SUB-CATEGORIES

—— SEPARATES LAND CATEGORIES

✦ DRILL HOLE LOCATIONS

ALWAYS THINK SAFETY

UNITED STATES
DEPARTMENT OF THE INTERIOR
WATER AND POWER RESOURCES SERVICE
EMRIA REPORT NO. 17-77
KINBETO STUDY AREA — NEW MEXICO

MAJOR LAND CATEGORIES

DESIGNED — SUBMITTED —
DRAWN — RECOMMENDED —
CHECKED — APPROVED —

AMARILLO, TEXAS JAN. 1978

Figure F-1

bedrock 60 inches or less below the surface lies near the badlands. Small areas of rock outcrops at various stages of weathering are scattered throughout valley lands. Valley lands were divided into two groups--sandy (v) (about 9 percent of the study area) and saline-sodic (s-a) (16 percent).

Sandy. Thirty-six percent of valley lands are covered by relatively shallow depths of eolian materials overlying saline-sodic deposits.

Topography is usually nearly level or gently sloping; some areas are undulating, some have blowouts, and a few have scattered hummocks. Some vegetation is supported by these lands, including coppice mounds (small mounds of soil material stabilized around vegetation).

Total depth of both surface and subsurface soils range from a few inches to more than 60 inches. Surface soils range from sand to sandy loam. Colors vary, with light yellowish brown, light brown, or pale brown being dominant. Structure usually is either single grain or granular. Subsoils are usually coarse textured, ranging from sand to sandy loam; however, loam and clay loam can be found in certain areas. Colors are grayish brown, brown, light brown, pale brown, or light yellowish brown. The sand subsoil structure is usually single grain or granular and in some places compact and cemented. The loam and clay loam subsoils are usually granular or blocky.

Permeability of the sandy material is usually moderately rapid to rapid. However, moisture penetration into the underlying part of the profile, where the finer textures usually occur, is generally very slow. Also, laboratory analysis of disturbed samples of some coarse-textured surface and subsurface soils indicates permeability is zero (see table Q-10). Available moisture holding capacity in surface soils is relatively low, but adequate to support and maintain vegetation with proper management.

Except for sodicity in a few isolated spots, most of the surface soils and sandy subsoils have no harmful accumulations of salinity or exchangeable sodium. The underlying finer textured materials, however, are usually saline-sodic, have very restricted permeability, are unstable, and will swell.

Although they have major deficiencies, soils of this group are suitable for use as planting media for reclamation purposes. Because they are subject to severe wind erosion, have a tendency to lack adequate water-holding capacity, and are highly permeable, these soils must be specially managed during stripping, stockpiling, and seeding.

Soil profiles 8, 22, 36, 40, and 49 (figures Q-25 through Q-35) are representative of these lands. The dominant soil series are Stumble, Turley, Notal, and Blancot.

Saline-sodic. These lands are characterized by soils with excessive salinity or sodicity or both. Scattered throughout these lands are patches of desert pavement (very thin layers of gravel or stones left on the land surface after removal of fines by wind action), slick spots (small areas slick when wet due to a high content of exchangeable sodium), and crust (usually 1/4 to 1-1/2 inches thick). Saline-sodic lands are nearly level or very gently sloping and dissected by drainageways and rills. Except for very shallow (6 to 12 inches thick) sandy eolian material on scattered areas, soils have developed from alluvial material. Near the badlands, on the upland valley slopes, are areas of local alluvium over residual geologic material. Soils are usually barren or have scattered sparse vegetation with thicker vegetation occurring in the eolian material. Coppice mounds also occur.

Most soils on the upland valley slopes, near the badlands, are shallow, usually 6 to 36 inches deep over weatherd shale and sandstone. The depths of the nearly level valley areas are usually greater than 60 inches, although soils less than 36 inches deep (and rock outcrops) occur in various locations. Weathered coal seams were encountered at various shallow depths, usually between the upland valley slopes and the nearly level valley lands.

Textures of surface soils range from loamy sand to clay. Colors are usually light yellowish brown, pale brown, brown, light brownish gray, grayish brown, or dark grayish brown. Structures are either single grain or granular. Subsoil and substratum textures range from sand to clay. Colors are similar to the surface tones. Structures are generally single grain, massive, or blocky.

Field observations and laboratory analysis indicate that permeability varies (table Q-10). Some of the surface and subsurface materials have sufficient moisture penetration for use as planting media. Where high amounts of sodic material occur, however, a sealing effect takes place that virtually prevents any moisture penetration. These highly sodic soils are therefore generally unsatisfactory for use as planting media. Soils with salinity exceeding the specifications for suitable planting media exist throughout these lands.

The best source of planting media is the sandy eolian material. Other sources of suitable material may be obtained from soil layers of acceptable quality (see table Q-10). Most of the saline-sodic soils are unsuitable as a source of planting media in their present condition. It may be possible, however, to improve some of these soils by mixing them with good quality media or by the addition of chemical additives, if additional soil is needed for revegetation.

Profiles 14, 18, 33, 58, 61, 73, and 85 are representative of these lands (figures Q-25 through Q-35). The dominant soil series are Blancot, Notal, Stumble, Turley, Huerfano, Tasaya, and Uffens.

Photo F-3. Looking east near profile 4 at Class 2 land in foreground, badlands in middleground, and mesa in background.

Photo F-4. Ah-Shi-Sle-Pah Wash west of profile 62, flanked by shaley coal cut-bank, with sandy land in background.

Badlands

Some of these lands are rough and steep or very steep, especially near the mesas, and have numerous intermittent drainage channels entrenched in soft shale or sandstone. Generally, badland surfaces consist of weathered shale and sandstone. Sandstone-capped pedestals occur in some places. Almost all of the badlands are barren, although a few spots of very sparse vegetation occur.

Although little or no soil development has occurred, fine textured, usually heavy, alluvial soils are usually present at or near the base of slopes. These soils are shallow, usually 2 to 12 inches deep, with textures ranging from sand loam to clay and generally mixed. Colors are grayish brown, dark grayish brown, brown, or mottled (the latter, especially, just above the shale or sandstone). Structure is usually blocky or granular.

Because of their high erosion hazard, very slow or no permeability, shallow depth, low natural fertility, strong sodicity, and excess salinity, these soils will provide little or no planting media. It may be desirable in a revegetation program to consider the use of some of these soils after mixing them with better quality media or treating them with additives to improve suitability.

Soil profiles 62 and 89 (figures Q-25 through Q-35) are representative of these lands where soil development has occurred. The dominant soil series are usually phases and variations of Huerfano, Uffens, Turley, Stumble, and Sheppard.

Miscellaneous

This category includes three groups--active dunes, hummocky areas, and stream channels.

Active dunes. Most of these lands consist of undulating land and small hills. Slopes vary widely, and local relief is 5 to 20 feet. Vegetation (near the dune margins) is sparse. Active dunes consist of sandy eolian desosits 60 inches or more in depth. The nature of surface layers varies, depending on the eroded parent material. Generally, textures range from fine sand to sand. Colors are usually light brown, pale brown, brown, or light yellow brown. The structure is single grain.

Permeability is very rapid, and available water-holding capacity is very low. Stability is critical because of high susceptibility to wind erosion. Most of these soils are considered unsuitable for planting media in their present state; however, mixing with better planting media may improve suitability.

Soil profile 90 (figures Q-25 through Q-35) is representative of the active dunes and is a coarse-textured phase of Sheppard.

Hummocky areas. These are undulating and rolling lands with slopes from zero to 20 percent. Small blowouts are scattered throughout. Vegetation, mostly greasewood and sage, covers nearly the entire area. Soils are derived from sandy eolian deposits, but alluvial material in the substratum is possible, especially near the washes.

Soil depth is usually 60 inches or more. Surface soil texture is usually loose fine sand or loamy fine sand. Colors are brown, light brown, or light yellowish brown. Structure is usually single grain but is sometimes slightly cemented, especially the surface 1 or 2 inches. Subsoil texture is usually fine sand, loamy fine sand, or sandy clay. Colors include brown, light brown, or light yellowish brown. Structure is usually single grain and sometimes cemented. Finer textured subsoils usually have an angular blocky structure.

Permeability is very rapid, and available water-holding capacity is low. The condition of surrounding soils indicates that some saline-sodic areas can be expected in hummocky lands.

The fact that these soils presently support vegetation indicates that they could be considered as a source of planting media. They were classified as unsuitable because of sodicity, coarse textures, and cemented surface conditions. However, they could be used if mixed with better quality media. Because of their coarse textures, special care must be taken to prevent severe wind erosion during stockpiling and replacement.

Soil profiles 30 and 54 (figures Q-25 through Q-35) are representative of hummocky areas. These soils consist of various phases of the Sheppard series, such as stabilized duned, rock outcrops (shale, sandstone, and coal), coarse-textured shallow phases, and saline-sodic phases.

Stream channels. This group consists of fluvial deposits in both Kimbeto and Betonnie Tsosie Washes. Random shallow deposits of eolian material also occur. The stream channels are almost barren, except where enough time has elapsed since the last flood to allow the growth of temporary vegetation.

Depth is 60 inches or more. Textures are usually sandy with some deposits of gravel and cobble; structure is single grain with colors of light brown, brown, or light yellowish brown.

These materials are flooded whenever runoff occurs and are generally moist to very moist. If transported from the confines of the channels, these materials would dry out very quickly because of their very low available water-holding capacity. These coarse-textured materials are subject to severe wind erosion if dry.

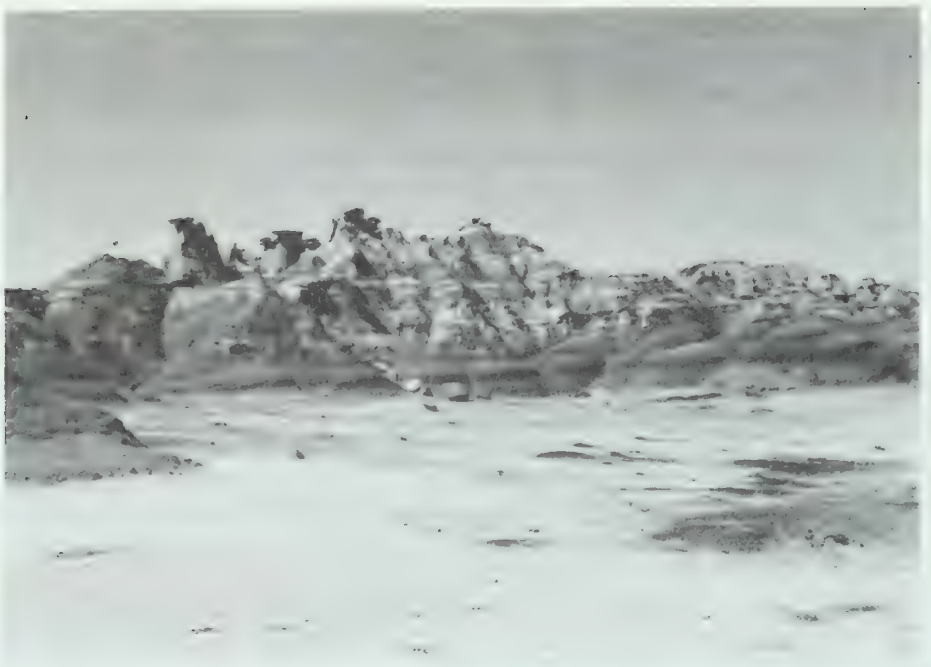


Photo F-5. Looking south near profile 62, at bare weathered shale and sandstone in foreground and badlands in background.

Photo F-6. Sandstone capped pedestals in badlands south of profile 63.

Use of fluvents for suitable planting media may be difficult. Their major limitations are combinations of instability, susceptibility to erosion, coarse texture, very low available water-holding capacity, and very low fertility.

Profile 52 (figures Q-25 through Q-35) is representative of these soils. Fluvents consist of many closely related materials that cannot be separated into specific soil series. They are deep, generally stratified, and widely varied in textures.

Land Suitability

Study area lands were surveyed and evaluated in order to classify them for their suitability as a source of material (planting media) for resurfacing the study area for revegetation (if surface mined). The survey provided data on the quality, quantity, and ease of stripping and stockpiling planting media and on other factors which affect suitability of the lands as a source of planting media.

Specifications were developed to enable this classification of study area lands for their suitability as a source of planting media. The specifications are the characteristics of the three land suitability classes--1, 2, and 6--established for the study area. The class numbers correspond to those in the Bureau of Reclamation's classification system. The specifications include quality considerations such as texture, salinity, sodicity, permeability, infiltration capacity, available water-holding capacity, and erodibility. The main quantity consideration was depth of suitable material. Stripping and stockpiling considerations included indurated bedrock exposures and excessive slope. The specifications are shown in table F-1.

Class 1 lands, the best source of planting media, should supply a large amount of highly suitable material relatively easy to stockpile. If not surface mined (due to depth of coal), Class 1 lands could probably serve as a borrow area for resurfacing areas with insufficient planting media.

Class 2 lands have planting media, but the media are of lower quality, difficult and expensive to handle, and limited in quantity.

Class 6 lands generally do not have suitable or sufficient planting media. Disturbance of these lands by surface mining or other operations will require, if the lands are to be revegetated, that planting media be borrowed or Class 6 materials be processed to provide planting media.

Procedures

Study area lands were evaluated for suitability for revegetation following surface mining. Physical and chemical soil characteristics, topography, and drainage were considered. Land forms were examined in sufficient detail to determine their character and extent. Field observations were confirmed by laboratory tests of representative soil profile samples.

Land classes and mapping units (see Soil Inventory, Section Q) were delineated in the field on aerial photographs (about 1" = 600'). The GS quadrangles were used for location and reference when mapping the land.

Most soils were bored, examined, sampled, and recorded to 10 feet. However, many borings were limited to less than 10 feet by shale or sandstone underlying most of the area. Additional soils were examined to determine texture and depth to barrier (bedrock). All soil profiles were located and recorded on the aerial photographs (see figures Q-25 through Q-35 for profile locations and descriptions and land classification).

A tile spade was used to examine the surface layers (topsoil). The lower soil profile was exposed for examination and sampling with a truck-mounted power soil auger.

Genetic soil horizons and the underlying stubstratum were studied in detail. Color, structure, texture, consistency, and soil moisture relationships (permeability and water-holding capacity) were observed, the last being the primary concern. The number and location of soil samples selected for laboratory analysis and greenhouse studies varied according to the particular conditions of the area.

A soils laboratory was extensively used to confirm the land classification done in the field. Screenable testing was conducted on all soil and bedrock samples. Additional tests were performed when more data were needed to support classification. (See Description of and References for Laboratory Procedures, Section Q, for procedures used in screenable testing.)

Many areas assigned certain classes may contain small amounts of soils of other classes, primarily near area margins where classes grade into others. Because the soils in both Classes 2 and 6 have deficiences, each class is divided into subclasses equivalent to certain deficiencies or combinations of deficiences. Table F-2 describes the planting-media characteristics of the classes and major subclasses.

The land classification symbols shown on figure F-2 (and figures F-3, F-4, and Q-25 through Q-35) describe the entire soil profile. Because areal projection of soil profiles based on test holes is less accurate below 36 inches, only the soil above this depth was evaluated for planting media; table F-2 presents this evaluation.

Summary of land classification results

Class 1 lands (23 percent of study area) are located on the mesas. Soils are generally medium to coarse textured and deep. They have no harmful accumulations of soluble salts or sodium and are permeable. Topographic features will not hinder strippings. Figures F-3 and F-4 show the location of the classes and subclasses.

Table F-2
Land Class and Major Subclass Characteristics 1/
Kimbeto Study Area

Land classes and subclasses 2/	Approximate acres	Major Chemical deficiency	Major Physical deficiency	Important soil and land characteristics	Suitability, stockpiling, placement, and management characteristics
All classes				All soil overburden can be stripped easily. Topography will not hinder reclamation, except on class 6s/-ap	Strip, transport, and stockpile carefully to prevent unplanned mixing. Mix soils carefully as necessary to improve poorer soils. Prevent poorer soils from directly or indirectly contaminating better soils. Protect from erosion during and after stockpiling and (as applicable) after revegetation. Protect revegetated areas from grazing until vegetation is well established.
1	2,821	None	None	Soils are deep, are coarser below 6 feet, have good permeability, adequate water holding capacity, some susceptibility to wind erosion, and are nonsaline and nonsodic.	Lands are best source of planting media. Manage revegetated areas normally.
Total class 1	2,821				
2s/v-	571	None	Coarse texture	Soils have moderately coarse textures, vary in depth, have good permeability and adequate water holding capacity for their class, and are susceptible to wind erosion. No major saline or sodic problems.	Lands are good source of planting media. Manage revegetated areas normally.
2s/vp-	336	None	Slow permeability	Soils have somewhat restricted permeability and moderate susceptibility to erosion. Saline and sodic problems not a major factor.	Lands are good source of planting media. Manage revegetated areas normally. Slow permeability will cause more than normal runoff; protect potentially affected areas.
Miscellaneous class 2 3/	559	Salinity	Slow and very slow permeability	Soils are somewhat saline. Permeability and water holding capacity somewhat restricted. Surface runoff anticipated.	Lands are fair source of planting media. If chosen for revegetation, careful management required.
Total class 2	1,466				
6s/ap-	766	Sodicity	Very restricted permeability or impermeable	Soils are saline-sodic affected. Most areas have no moisture penetration and rapid runoff occurs. Soils are susceptible to erosion.	Although not recommended, careful mixing of these shallow soils with better material may be acceptable if their use is absolutely necessary. Selection, handling, and placement must be very carefully done to assure reasonable success in use of this material. Take special care to prevent contamination of better soils. Place unsuitable material well below root zone. Limited permeability or surface sealing will cause more than normal runoff; protect potentially affected areas. If soils are chosen for revegetation, the very careful management required will be difficult.
6s/-ap	5,026	Saline-sodic affected geologic material	Impermeable	This is primarily saline-sodic affected, impermeable geologic material. Rapid runoff occurs.	Although not recommended, careful mixing of these materials with high quality soils may be acceptable if material for mixing is critically needed. Place unsuitable material well below root zone. Impermeability will cause rapid runoff; protect potentially affected areas. Management will be extremely difficult.
6s/ap-ap	691	Sodicity	Very restricted permeability or impermeable	Soils are saline-sodic affected. Most areas have no moisture penetration and have poor water holding capacity. Rapid runoff occurs. Soils are susceptible to erosion.	Soils are not recommended for use, but careful mixing of these soils with better material may be acceptable if their use as planting media is absolutely required. Selection, handling, and placement must be very carefully done to assure success in use of these soils. Take special care to prevent contamination of better soils. Place unsuitable materials well below root zone. Limited permeability or surface sealing will cause more than normal runoff. Very careful management required.
Miscellaneous class 6	1,380				
Total class 6	7,873				
Grand Total	12,160				

1/ This table applies to about the top 36 inches of overburden at the study area. Lands were classed for their suitability as a source of planting media as follows:

Class	Suitability
1	good
2	fair
6	unsuitable in present condition

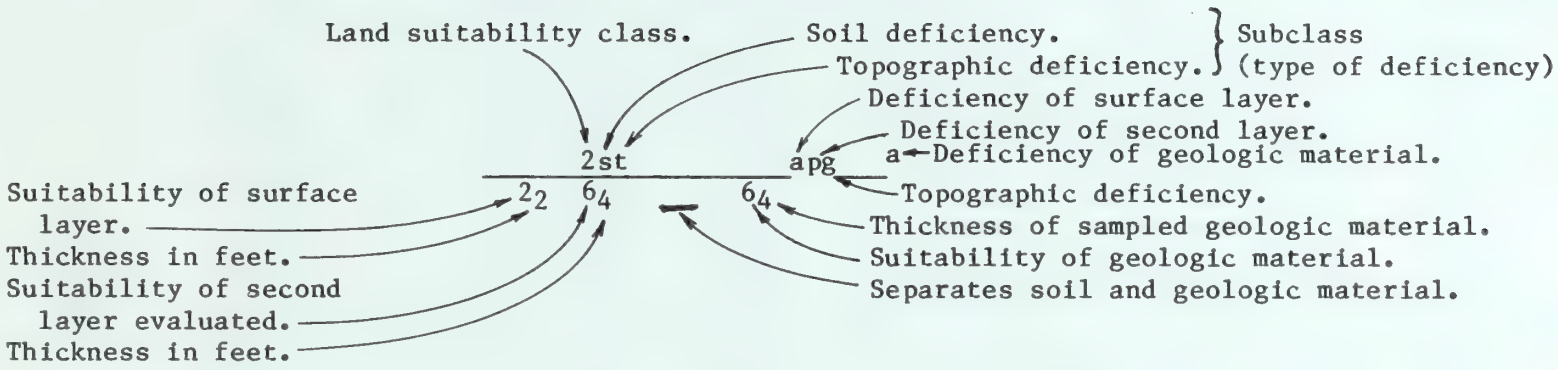
2/ 2s/v-p
- 2 = land class
- s = letter indicates subclass (type of deficiency): soil (s) or topography (t)
- v = major deficiency, above geologic material
- p = major deficiency of geologic material

v = very coarse; a = sodic; p = permeability; s = saline; g = slope

This nomenclature is similar to that of figure F-2.

3/ Classes with less than 10 acres.

Land Classification Symbols



Land suitability class
- 1 good
- 2 fair
- 6 unsuitable

Subclasses
- s - soils
- t - topography

Subclass deficiency (soil or geologic material)
- v - very coarse texture
- a - sodic
- p - permeability
- s - saline
- k - shallow depth to coarse sand, gravel, or cobble
- g - slope

Figure F-2

T23N
T22N
R11W
R10W

6
5
4
12
7
8
9
18
17
16
19

MATCH LINE TO SHEET 2

EXPLANATION:

LAND CLASSIFICATION	ACRES
CLASS 1	2,821
CLASS 2	1,466
CLASS 6	7,873
TOTAL (SHEETS 1 & 2)	12,160

N

2000 0 2000
SCALE OF FEET

ALWAYS THINK **SAFETY**

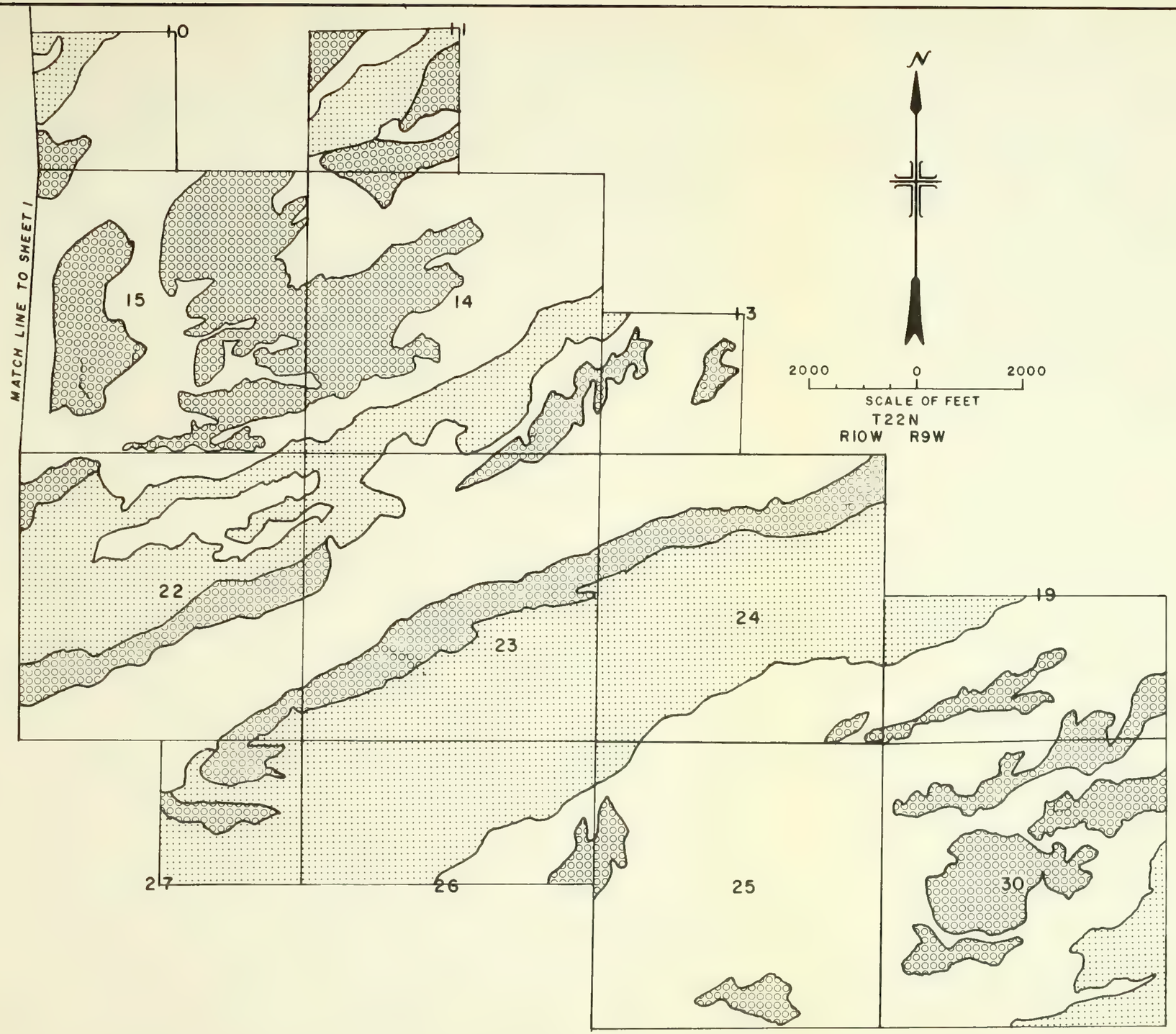
UNITED STATES
DEPARTMENT OF THE INTERIOR
WATER AND POWER RESOURCES SERVICE
EMRIA REPORT NO. 17-77
KIMBETO STUDY AREA - NEW MEXICO

GENERAL LAND CLASSIFICATION

DESIGNED _____ SUBMITTED _____
DRAWN _____ RECOMMENDED _____
CHECKED _____ APPROVED _____

AMARILLO, TEX. JAN. 1978
SHEET 1 OF 2

Figure F-3



EXPLANATION:

LAND CLASSIFICATION		ACRES
	CLASS 1	2,821
	CLASS 2	1,466
	CLASS 6	7,873
	TOTAL (SHEETS 1&2)	12,160

ALWAYS THINK SAFETY

UNITED STATES
DEPARTMENT OF THE INTERIOR
WATER AND POWER RESOURCES SERVICE

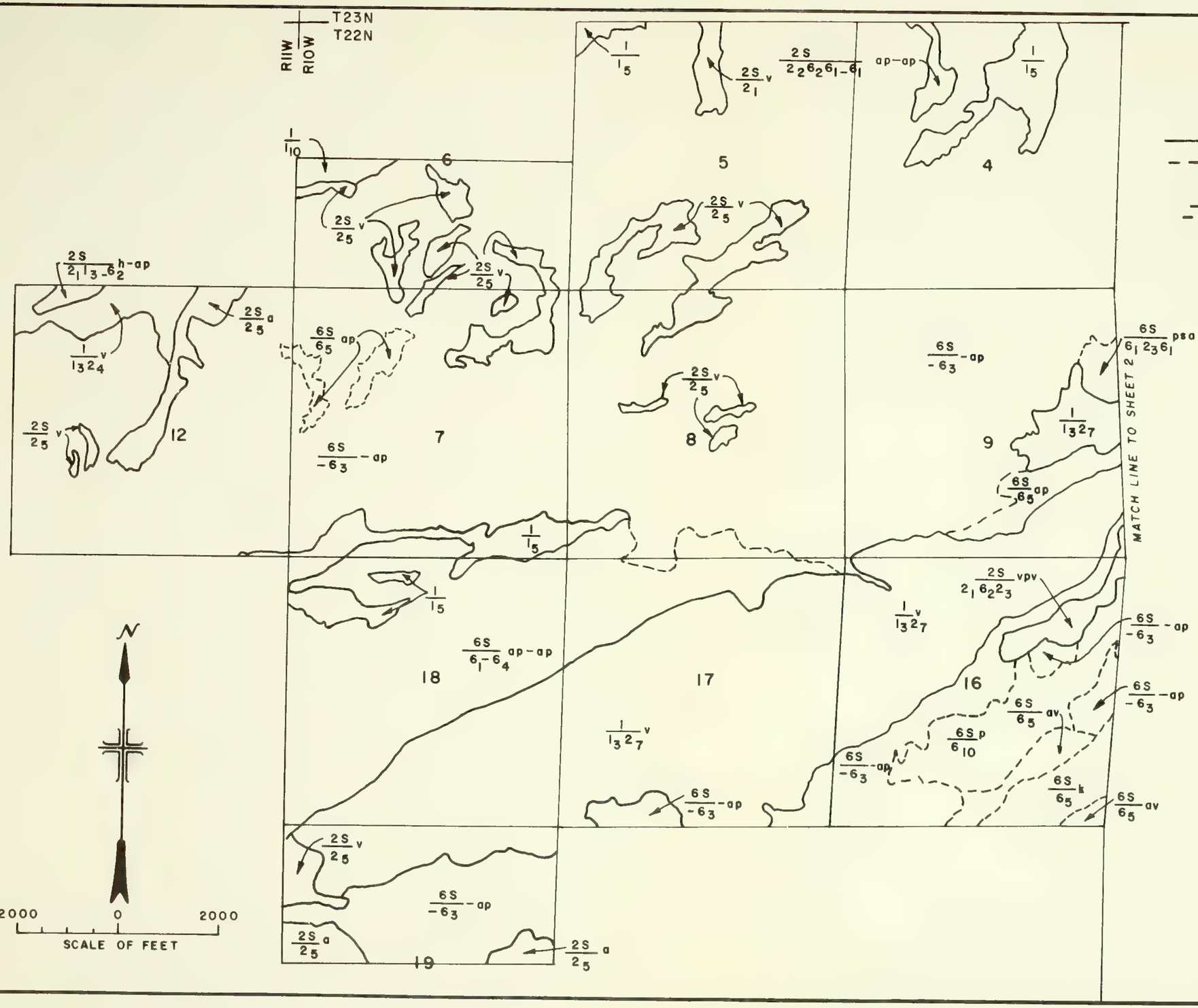
ENGR. REPORT NO. 17-77
RINCON STUDY AREA - NEW MEXICO

GENERAL
LAND CLASSIFICATION

DESIGNED _____ SUBMITTED _____
DRAWN _____ RECOMMENDED _____
CHECKED _____ APPROVED _____

AMARILLO, TEX. JAN. 1978

Figure F-3



EXPLANATION:

SEPARATES LAND CLASSES

SEPARATES SUBCLASSES

$\frac{6S}{-6_3}-a$ LAND CLASS SYMBOL *

* SEE TABLE F-2 FOR CHARACTERISTICS OF LAND CLASSES AND MAJOR SUBCLASSES

ALWAYS THINK SAFETY

UNITED STATES
DEPARTMENT OF THE INTERIOR
WATER AND POWER RESOURCES SERVICE

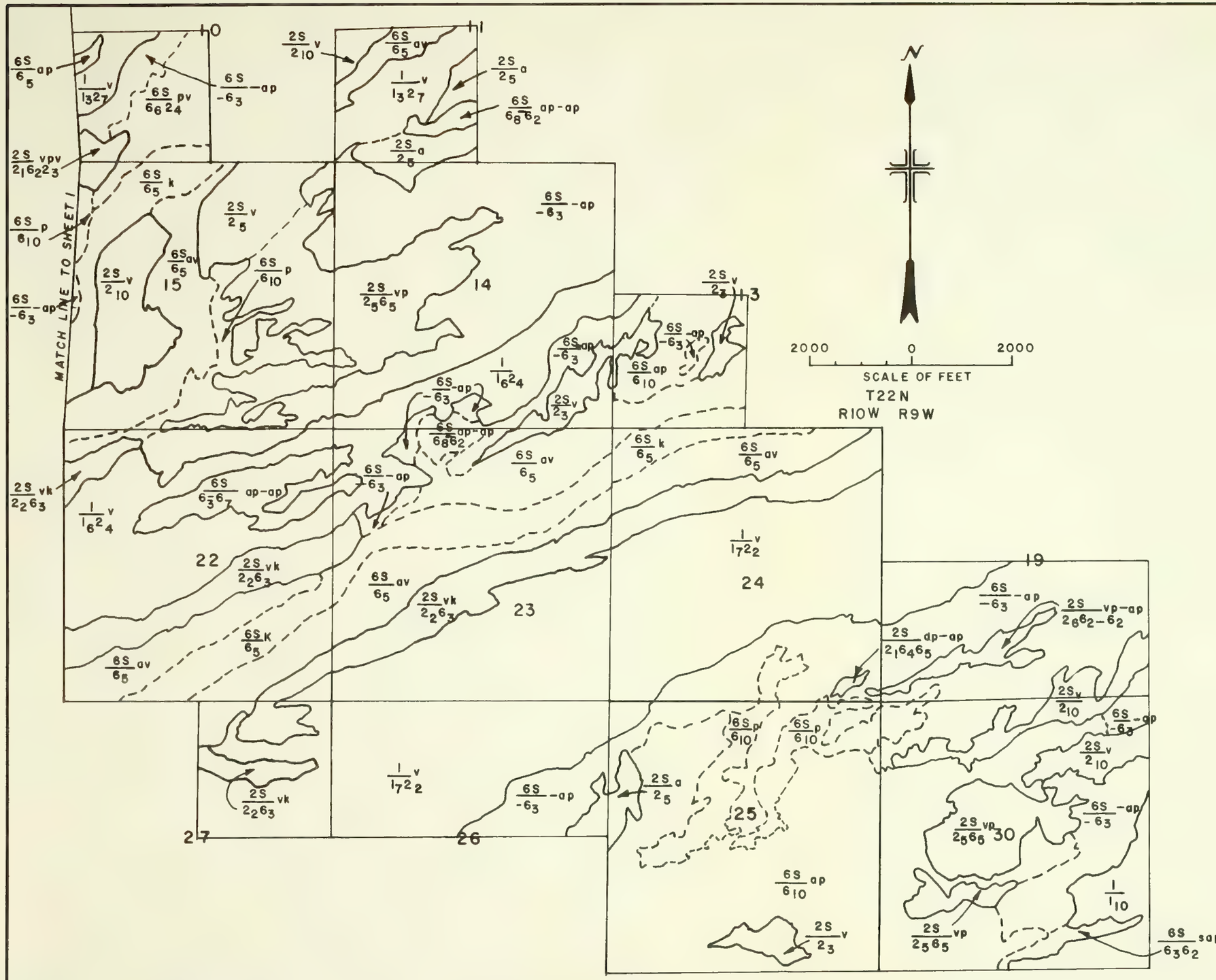
EMRIA REPORT NO. 17-77
KIMBETO STUDY AREA - NEW MEXICO

DETAILED
LAND CLASSIFICATION

DESIGNED _____ SUBMITTED _____
DRAWN _____ RECOMMENDED _____
CHECKED _____ APPROVED _____

AMARILLO, TEX. JAN. 1978
SHEET 1 OF 2

Figure F-4



EXPLANATION:

——— SEPARATES LAND CLASSES

– – – – – SEPARATES SUBCLASSES

$\frac{6S}{-6_3}-a$ LAND CLASS SYMBOL*

* SEE TABLE F-2 FOR CHARACTERISTICS OF LAND CLASSES AND MAJOR SUBCLASSES

ALWAYS THINK SAFETY

UNITED STATES
DEPARTMENT OF THE INTERIOR
WATER AND POWER RESOURCES SERVICE

EWRIA REPORT NO. 17-77
KIMBETO STUDY AREA – NEW MEXICO

DETAILED
LAND CLASSIFICATION

DESIGNED — SUBMITTED —
DRAWN — RECOMMENDED —
CHECKED — APPROVED —

AMARILLO, TEX. JAN. 1978 SHEET 2 OF 2

Figure F-4

Class 2 lands (12 percent of study area) are located on mesas, sandy ridges, and in the valleys. Soils are generally medium to coarse textured and shallow to deep. For the most part, there are no large amounts of salinity or sodium and permeability is good, although a few areas do have harmful accumulations with restricted permeability. Topography will not hinder stripping.

Class 6 lands (65 percent of study area) are located in all areas of the study area. Soils range from fine to coarse textures and from shallow to deep. All have harmful accumulations of salinity and sodium and very rapid to very restricted permeability. Bedrock outcrops occur. Topography will hinder stripping.

Bedrock Suitability

Bedrock materials at the Kimbeto study area are in two geologic formations--the Fruitland and Kirtland. The materials in these formations are discussed in section C (especially the Study Area Geology subsection).

The results of selected physical and chemical tests performed on overburden and on materials separating coal beds are summarized in tables Q-10 and Q-11. The materials were obtained as core samples from drill holes DH-1 through DH-10 located as shown on figure C-1.

Twelve samples of overburden and coal seam separations fron DH-1 were subjected to mechanical analysis. The analysis showed that the average particle size distribution of the materials is 31.5 percent clay, 43.3 percent sand, and 25.2 percent silt. The samples were either sandstone or shale. Since all the study area samples of bedrock overburden and coal seam separations were sandstone or shale, and since all such samples are from the same formations, it was considered unnecessary to subject samples from other DH's to mechanical analysis.

In weathering tests, breakdown of bedrock after 20 laboratory cycles or 1 year of outdoor exposure varied greatly from no breakdown to complete breakdown. For 10 samples subjected to freeze-thaw (laboratory cycles) tests, the range of breakdown was: 0-10 percent--5 samples, 10-50 percent--4 samples, above 50 percent--1 sample. No samples had 100 percent breakdown. Of those samples subjected to 1 year of outdoor weathering, 60 percent showed slight breakdown, 20 percent showed little to no breakdown, and 20 percent showed complete breakdown (see Results of Weathering Tests in section Q).

Disturbed hydraulic conductivity (table Q-10) was zero for all core samples. Therefore, if not topsoiled and properly managed, bedrock spoil piles may develop a surface crust and be relatively impermeable to infiltration from precipitation. Also, leaching of chemicals from the surfaces of bedrock spoil piles by runoff could be higher than leaching now occurring; likewise, wind erosion and blowing dust could be higher than erosion and dust now occurring.

The swell factor of excavated rock from the Kirtland Shale and Fruitland Formation is unknown but is expected to be relatively high because of the presence of appreciable amounts of montmorillonite in the shales, as is indicated by the cation exchange capacity (CEC) (table Q-10). The CEC for 131 samples ranged from 1.6 to 64.2, averaging 27.3.

The total of 25 chemical analyses of saturated past extract (table Q-10) indicates consistently high concentrations of sodium in most of the overburden and materials separating coal beds. Sodium concentrations ranged from 8.4 milliequivalents per liter (meq/l) to 86.0 meq/l, averaging 34.0 meq/l. Electrical conductivity (EC x 10^3 @ 24° C) ranged from 1.0 to 8.0 millimhos per centimeter, averaging 3.0. High levels of sodium such as these can adversely affect plant growth and soil permeability.

The above tests and others (see table Q-10) and field investigations indicate that most bedrock materials are unsuitable as planting media. Revegetation of overburden spoil piles at the nearby Navajo Coal Mine indicates, however, that germination and young plant establishment on some bedrock material are possible under irrigation. Therefore, it may be possible at the area to mix some planting media with selected bedrock materials and achieve success. The levels of sodium and clay in the bedrock thus could possibly be reduced. This must remain speculation until research identifies usable types of bedrock and determines the permanency of revegetation established by irrigation when irrigation is withdrawn.

The removing, transporting, and stockpiling of bedrock material must be well managed to prevent contamination of planting media and water supplies.

Toxic Materials

Selected tests (table Q-10) and greenhouse studies*/ of samples from the study area indicate no significant accumulations of toxic materials other than sodium. If a more detailed soil survey is conducted prior to mining, additional toxic materials or materials unfavorable for plant growth may be found. In this event, these materials must be properly identified and plans made to dispose of them so that planting media and water supplies are not contaminated.

Additional Studies Before Mining

Before soils of the study area are disturbed, the land classification conducted for this report should be refined to assure more accurate identification and proper disposition of all soils.

The field investigations, weathering tests, greenhouse studies, and laboratory analyses of study area bedrock were all performed on selected core (DH) materials. Data derived from these investigations, etc., represent only specific drill hole sites and should not be projected without additional investigations of the study area.

*/ Characterization of Strata Overlying Coal Seams as Plant Growth Media, in section Q.

Photo F-7. Looking west near profile 8 at Class 2 land, with some badlands on left and right.

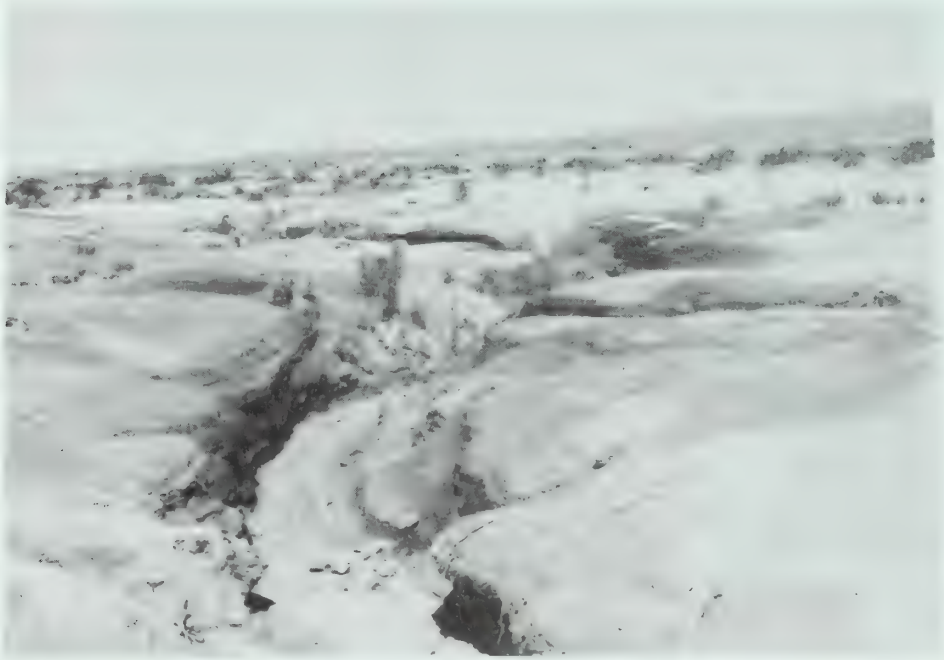


Photo F-8. Looking north, southwest of profile 62, at erosion and bare weathered shale and sandstone with some coal in foreground and small slightly vegetated sandy ridges and mesa in background.

Because of the study area's severe climatic and soil conditions, its post-mining reclamation will be very challenging, allowing only a moderate chance of success. To improve the chances of successful reclamation, additional research should be conducted, including the use of on-site test plots and covering considerations such as soil treatment (as with gypsum), use of irrigation, erosion control, plant species, and management of revegetated areas.

Quality Of Irrigation Water Supplies

Please refer to section J and the Hydrology and Water Supply subsection of section L for an evaluation of the quality of water supplies to be used in revegetating the study area.

SECTION G

VEGETATION

SECTION G

VEGETATION

Aerial cover and soil surface conditions (bare soil, rock, and mulch) at each sampling site were measured in late September 1976 by the first-contact point-quadrat method. A frame containing 10 vertical pins was placed at three step intervals requiring about one-tenth mile to obtain 600 pin measurements in each vegetation type. Current growth of vegetation and mulch were measured in three 9.6 ft^2 plots in each type. Plant materials were oven dried and weighed, and are reported as pounds per acre (table G-1).

Several factors contribute to the low productivity of the sites sampled. Annual precipitation is low--about 9 inches. Much of the precipitation falls as high-intensity thunderstorms that cause high runoff and reduce water availability for upland vegetation. Also, many years of use by domestic livestock have caused undesirable changes in kinds of plants present and have reduced the vigor and productivity of the remaining species of the original vegetation. In addition, certain geologic materials, such as exposed clayey shales, have resulted in non-productive soils that have always been barren. Relatively high temperatures, often over 100°F in summer, result in high evaporation and reduced plant yields. Slightly lower than normal precipitation during the year of sampling (1976) may have caused vegetation yields to be lower than normal.

The vegetation is a part of the southernmost extent of the northern desert shrub type. Typical northern desert shrub species present are big sagebrush (Artemisia tridentata), shadscale (Atriplex confertifolia), and rubber rabbitbrush (Chrysothamnus nauseosus). Galleta (Hilaria jamesii) and ring muhly (Muhlenbergia torreyi) are species found only in the southern portion of the northern desert shrub type.

Exposed clayey shales in the area have almost no vegetation and were mapped as "barren" (site 4, fig. G-1). Other terms used to describe the type are "badlands" and "waste" because it produces minimal forage for livestock grazing. Plants occur only in favorable niches, such as depressions, where sediment and runoff accumulate. The type was unique in that only there was the presence of shadscale recorded. The rare and endangered (threatened) forb, milkvetch (Astragalus accumbens) is reported to occur on gray clays of northwestern New Mexico, but none was observed.

The spearleaf saltbush (Atriplex patula hastata) type (table G-1) is a subdivision of the barren type and is also essentially useless for grazing. It occurs on soils affected by exposed and weathered coal. Live plant cover for this type is only 4.3 percent. Here, also, plants are found only in favorable sites where run-in moisture accumulates. Only four species occurred in the sample plots.

Big sagebrush-galleta (site 1, table G-1) occupies the extensive, relatively flat and sandy uplands. This favorable site for plant growth had the most species present (15) of the sites sampled. In general appearance it is a grassland with scattered shrubs. On similar but higher mesas to the east and north of the study area, big sagebrush cover increases and blue grama (Bouteloua gracilis) becomes more abundant than galleta.

One of the nearly pure grassland types sampled is alkali sacaton (Sporobolus airoides) (site 2) which occurs on shallow sands deposited in and near upland channels. The site is characterized by alternate grass-covered shallow sands and barren exposed fine-textured alluvium. If the shallow sands were continuous, plant yields would be much higher.

Adjacent to the big sagebrush-galleta type is the galleta-false buffalograss (Munroa squarrosa) type (site 5). This type also occurs on shallow sands, but unlike the alkali sacaton type, does not receive run-in moisture. This heavily grazed type has an abundance of the invading exotic species, Russian thistle (Salsola kali) which contributes about 78 percent to the total vegetation yield.

Greene's rabbitbrush (Chrysothamnus greenei)-blue grama (site 3) commonly occurs on east-facing slopes with shallow upland soils. Although the type probably receives blow-in snow, forage production is low.

The alkali sacaton-greasewood (Sarcobatus vermiculatus) type (site 7) and the alkali sacaton-rubber rabbitbrush type (site 10) are similar in many respects. Both occur on alluvium of major drainage channels but the stable dunes of the alkali sacaton-rubber rabbitbrush are somewhat deeper, about 15 feet for the latter and 4-5 feet over fine alluvium for the alkali sacaton-greasewood type. The deeper sands occur below the junctures of tributaries. As is true of the alkali sacaton (site 2), productivity of these sites is reduced by interspersed barren fine-textured alluvium. The alkali sacaton-rubber rabbitbrush type has greater species diversity (13 as compared with 5) but lower forage production than the alkali sacaton-greasewood type.

A type dominated by rubber rabbitbrush occurs as narrow bands on alluvial sands at the edges of major stream channels. This is a productive site but, because of the low palatability of the dominant species, carrying capacity of the type would be low.

Greasewood (site 9) occupies salty soils on slopes and lower terraces adjacent to major tributaries. Salty soils are probably caused by the rise of water to the surface from shallow ground water. Other salt-tolerant species are seepweed (Suaeda fruiticosa) and alkali sacaton. Low palatability of greasewood causes useable forage on this site to be low.

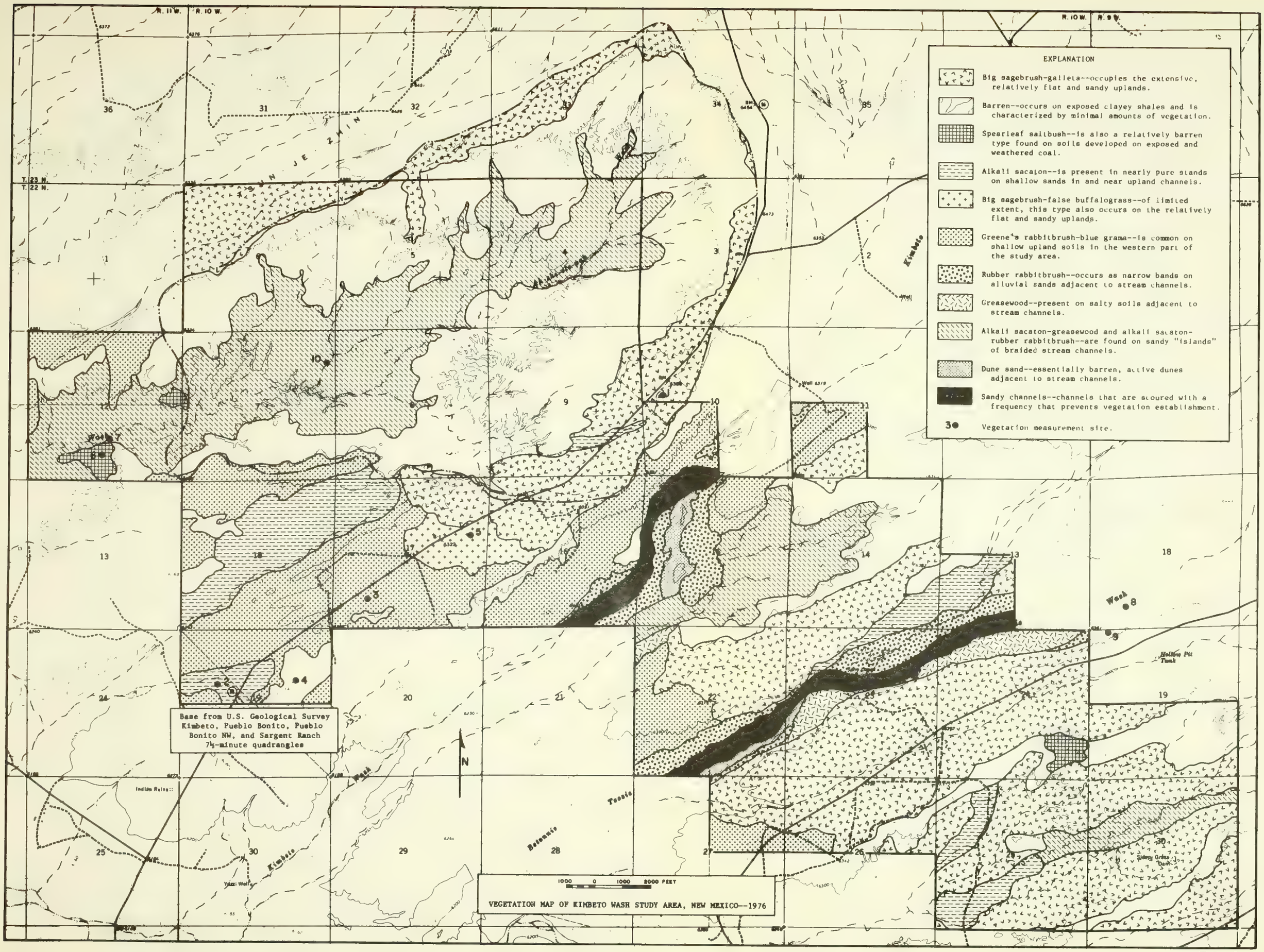

EXPLANATION
Big sagebrush-galleta--occupies the extensive, relatively flat and sandy uplands.
Barren--occurs on exposed clayey shales and is characterized by minimal amounts of vegetation.
Spearleaf saltbush--is also a relatively barren type found on soils developed on exposed and weathered coal.
Alkali sacaton--is present in nearly pure stands on shallow sands in and near upland channels.
Big sagebrush-false buffalograss--of limited extent, this type also occurs on the relatively flat and sandy uplands.
Greene's rabbitbrush-blue grama--is common on shallow upland soils in the western part of the study area.
Rubber rabbitbrush--occurs as narrow bands on alluvial sands adjacent to stream channels.
Greasewood--present on salty soils adjacent to stream channels.
Alkali sacaton-greasewood and alkali sacaton-rubber rabbitbrush--are found on sandy "islands" of braided stream channels.
Dune sand--essentially barren, active dunes adjacent to stream channels.
Sandy channels--channels that are scoured with a frequency that prevents vegetation establishment.
Vegetation measurement site.
R. 11 W.
R. 10 W.
R. 9 W.
T. 23 N.
T. 22 N.
Base from U.S. Geological Survey Kimbeto, Pueblo Bonito, Pueblo Bonito NW, and Sargent Ranch 7½-minute quadrangles
N
1000 0 1000 2000 FEET
VEGETATION MAP OF KIMBETO WASH STUDY AREA, NEW MEXICO--1976

FIG. G-1

Table G-I.--Percentage ground cover and annual yields of vegetation at representative sites in September 1976

[Yields are in parentheses]

	Vegetation type . . .	Big sagebrush-Galleta		Alkali sacaton		Greene's rabbitbrush-Blue grama		Barren		Galleta-False buffalograss		Spearleaf saltbush		Alkali sacaton-Greasewood		Rubber rabbitbrush		Greasewood		Alkali sacaton-Rubber rabbitbrush	
	Site number	1		2		3		4		5		6		7		8		9		10	
Genus and species	Common name	Cover	Yield	Cover	Yield	Cover	Yield	Cover	Yield	Cover	Yield	Cover	Yield	Cover	Yield	Cover	Yield	Cover	Yield	Cover	Yield
Shrubs																					
Artemisia filifolia	Sand sagebrush	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	0.3	-----
Artemisia tridentata	Big sagebrush	10.2	(34)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	1.2	-----	-----	-----	1.7	(8)
Atriplex confertifolia	Shadscale	-----	-----	-----	-----	-----	-----	2.3	(6)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	0.7	-----
Atriplex obovata	Broadscale saltbush	-----	-----	0.4	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Chrysothamnus greenei	Greene's rabbitbrush	-----	-----	-----	-----	14.8	(62)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	0.7	(7)
Chrysothamnus nauseosus	Rubber rabbitbrush	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	0.8	(1)	-----	-----	32.8	(629)	-----	-----	2.8	(48)
Gutierrezia sarothrae	Snakeweed	0.4	-----	-----	-----	2.2	(43)	-----	-----	1.7	(16)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Opuntia polyacantha	Plains pricklypear	0.2	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Sarcobatus vermiculatus	Greasewood	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	0.7	(8)	-----	-----	11.8	(93)	-----	-----
Suaeda fruiticosa	Seepweed	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	3.0	(57)	-----	-----
Grasses																					
Agropyron smithii	Western wheatgrass	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	0.5	(1)	-----	-----	-----	-----
Bouteloua barbata	Sixweeks grama	0.3	-----	-----	-----	-----	(5)	-----	-----	-----	-----	-----	-----	0.7	(1)	0.5	(3)	-----	(5)	0.2	(23)
Bouteloua gracilis	Blue grama	2.5	(0.3)	-----	-----	5.3	(36)	-----	-----	2.2	(0.3)	-----	-----	-----	-----	-----	-----	0.2	(2)	0.3	(5)
Calamovilfa longifolia	Prairie sandreed	-----	(8)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	(7)	-----	-----	-----	-----
Distichlis stricta	Saltgrass	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	1.3	(8)	-----	-----	-----	-----
Hilaria jamesii	Galleta	7.0	(202)	1.6	(8)	3.7	(79)	-----	-----	9.5	(107)	-----	-----	0.5	-----	-----	-----	0.7	-----	3.0	-----
Muhlenbergia torreyi	Ring muhly	-----	-----	-----	-----	-----	(4)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	3.8	-----
Munroa squarrosa	False buffalograss	0.7	(0.3)	0.1	-----	0.2	(23)	-----	-----	2.8	(49)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Oryzopsis hymenoides	Indian ricegrass	0.3	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	0.3	(7)	-----	-----	3.2	(6)
Sporobolus airoides	Alkali sacaton	2.4	-----	21.6	(244)	-----	-----	1.5	(1)	-----	-----	1.5	(1)	13.2	(125)	0.2	(7)	12.7	(118)	14.8	(67)
Sporobolus cryptandrus	Sand dropseed	0.3	-----	-----	-----	0.7	(1)	-----	-----	0.2	(0.3)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Forbs																					
Atriplex patula hastata	Spearleaf saltbush	0.2	-----	-----	(7)	-----	-----	0.7	(1)	-----	-----	1.5	(1)	-----	-----	-----	-----	-----	-----	-----	-----
Euphorbia sp.	Mat spurge	0.1	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Salsola kali	Russian thistle	3.5	(12)	0.6	(1)	2.2	(54)	-----	-----	14.3	(599)	0.5	-----	1.3	(46)	-----	-----	-----	-----	1.8	(2)
Sphaeralcea coccinea	Scarlet globemallow	-----	-----	-----	-----	-----	(1)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
	Unidentified forbs	0.2	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	(6)	-----	(11)	-----	-----	0.2	(20)
Total live cover (percent) or total vegetation yield (lb/acre)		28.3	(262)	24.3	(260)	29.1	(308)	4.5	(8)	30.7	(777)	4.3	(3)	16.4	(186)	36.8	(673)	28.4	(275)	33.5	(186)
Mulch		16.3	(640)	6.2	(102)	11.3	(90)	0.7	(1)	13.5	(69)	0.2	-----	6.7	(115)	9.0	(190)	10.7	(384)	5.8	(67)
Bare soil		55.3		67.7		59.7		88.5		55.8		73.7		77.0		54.2		61.0		60.7	
Rock		-----		1.8		-----		6.3		-----		21.8		0.7		-----		-----		-----	

SECTION H

SOIL-MOISTURE RELATIONSHIPS ASSOCIATED WITH VEGETATION TYPES AND LANDFORMS

SECTION H

SOIL-MOISTURE RELATIONSHIPS ASSOCIATED WITH VEGETATION TYPES AND LANDFORMS

Soil-moisture relationships are important in rehabilitation because they influence infiltration, permeability, revegetation, and erosion. Interpretations of soil-moisture relationships were based on the theories discussed in section R.

Soils were sampled in October 1976 at 21 sites on the study area, the locations of which are shown in figure H-1. The sites were selected within each important vegetation type to represent the range of soils found in the area. Where possible, the series of each soil was identified from preliminary soil survey mapping of San Juan County, New Mexico, done by the USDA, Soil Conservation Service (SCS) (written commun.). Simple laboratory procedures were utilized to obtain the key variables for interpreting the soil-moisture relationships of each site. The key variables include moisture-retention capability (MRC), adsorption-moisture capability (AMC), void-moisture capacity (VMC), and average annual minimum storage of moisture (MS). Definitions of these variables and procedures for determining their values are given in section R. All of the data obtained for these and other supplementary variables are listed in section R, table R-1.

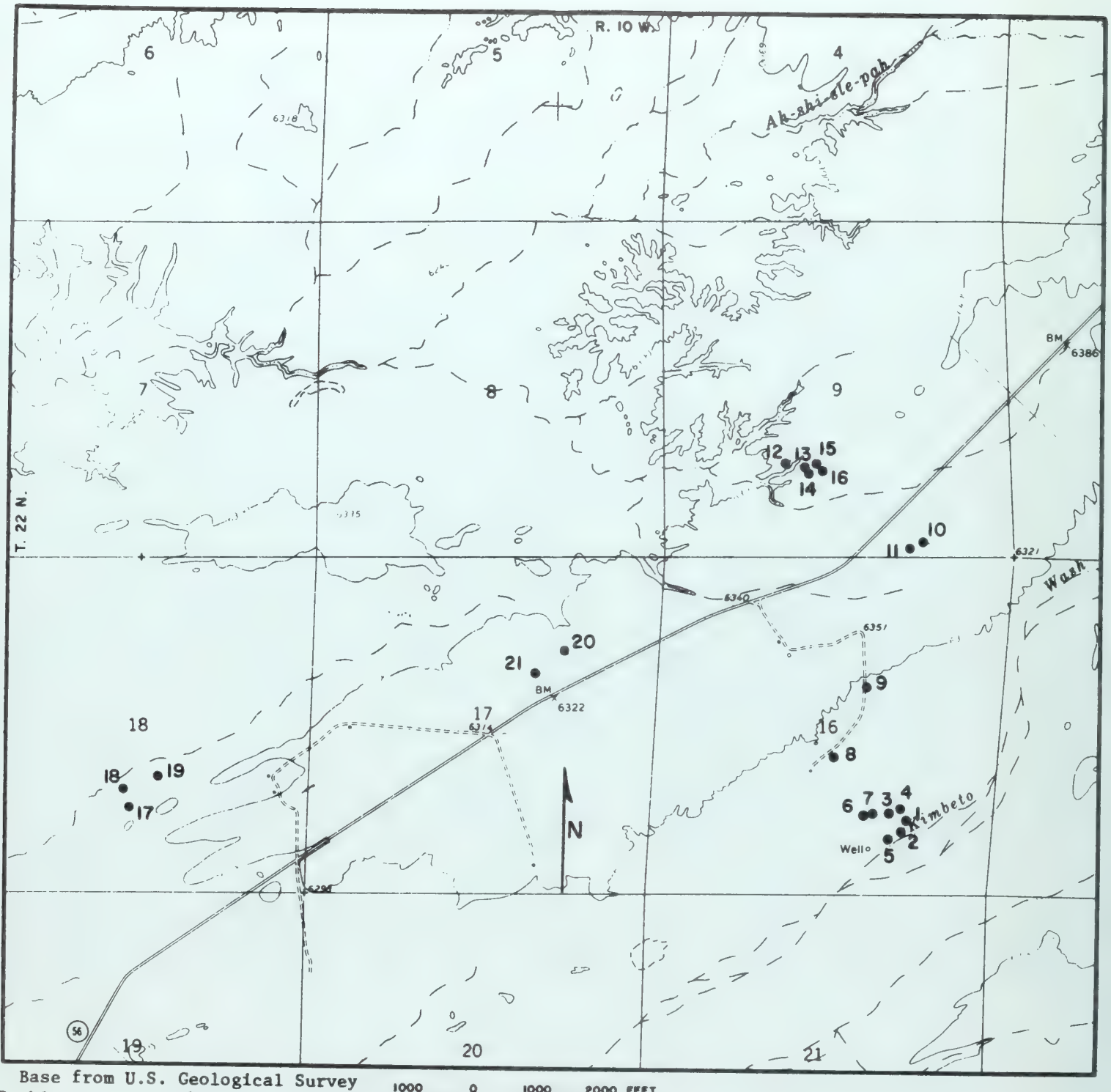
The values that appear within each of the retention force versus depth graphs that follow are depths of water in millimeters that can be held in the profile between VMC and MRC moisture contents and between MRC and MS moisture contents (507 and 23 in figure H-2). The amount of water held between MRC and MS levels represents a single normal annual storage. Water added from precipitation events other than those causing the peak storage is not included in the values in the graphs. The values, therefore, are only an index of actual annual evapotranspiration.

The values between VMC and MRC represent excess void space that is not filled at MRC levels. That space can be partly or wholly filled, temporarily, in a permeable soil or over an extended period in a soil with a drainage constriction. Infiltration and permeability are proportional to the amount of void space between VMC and MRC.

Sites occurring on the same or a similar landform were grouped. Variations within each landform group are discussed and comparisons among groups are made in the remainder of this section.

Dunes

The dunes group includes sites 1, 2, 8, 9, 13, 15, and 16 (see figs. H-2 and H-3, and table H-1). Sites 1 and 2 are located on a stabilized vegetated dune adjacent to Kimbeto Wash. SCS mapping classifies this area as riverwash, but these profiles are aeolian deposits over fluvial deposits. The material probably was transported by wind from the barren channel beds to the sites. During field sampling, water was observed in the auger holes after the lowermost samples were removed. The decreasing retention forces, below MRC levels, in the lower parts of the profiles indicate "capillary-rise" zones above water tables (fig. H-2).



Base from U.S. Geological Survey
Pueblo Bonito NW 7½-minute quadrangle

Figure H-1.--Locations of sampling sites for defining moisture relations in soils of the Kimbeto Wash EMRIA study area, New Mexico--1976.

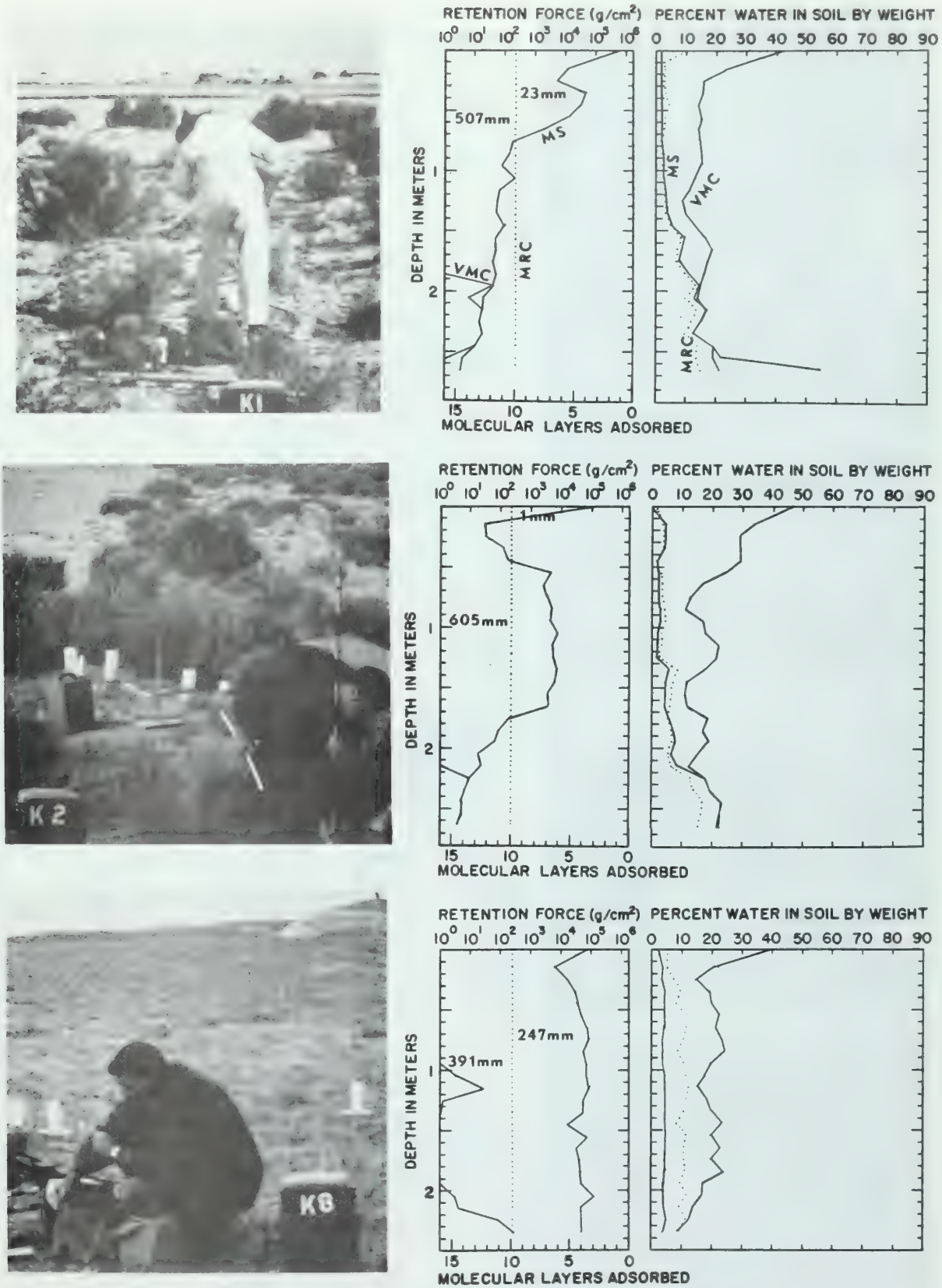


Figure H-2. --Moisture relations in soils of dune sites; sites 1 and 2 are on stabilized dunes adjacent to Kimbeto Wash, and site 8 is on a nearby sandy alluvial apron.

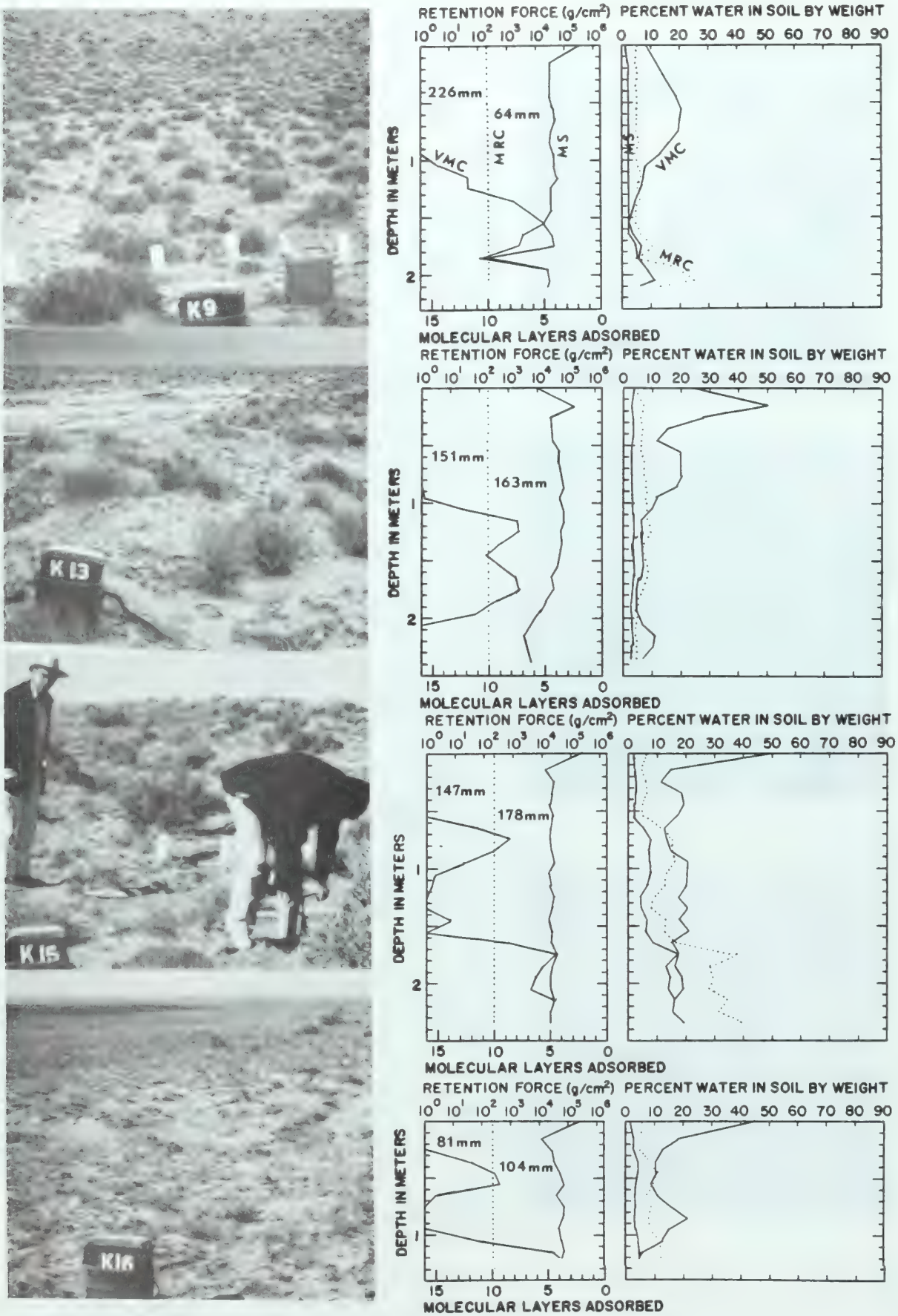


Figure H-3.--Moisture relations in soils for sites on stabilized upland dunes.

Table H-1.--Vegetation cover, in percent, at dunes sites

Species		Sites						
Latin name	Common name	1	2	8	9	13	15	16
Shrubs								
Artemisia tridentata	Big sagebrush	--	--	--	4	2	5	--
Atriplex confertifolia	Shadscale	--	--	--	--	9	3	--
Chrysothamnus greenei	Greene's rabbitbrush	--	--	--	21	7	13	--
Chrysothamnus nauseosus	Rubber rabbitbrush	12	35	--	--	3	--	--
Eriogonum sp.	Eriogonum						1	
Gutierrezia sarothrae	Broom snakeweed	--	--	--	1	--	--	--
Opuntia polycantha	Plains pricklypear	--	--	--	--	--	--	2
Grasses								
Bouteloua eriopoda	Black grama	2	--	9	14	--	8	5
Distichlis stricta	Saltgrass	--	6	--	--	--	--	--
Hilaria jamesii	Galleta	--	--	20	--	--	14	13
Muhlenbergia torreyi	Ring muhly	--	--	--	--	28	4	--
Sporobolus airoides	Alkali sacaton	27	2	18	--	--	--	11
Forbs								
Salsola kali	Russian thistle	--	--	1	--	--	--	13
	Unidentified forbs	--	--	--	1	--	--	--
Mulch		2	--	--	--	5	--	--
Bare soil		57	57	52	59	46	52	56
Total live cover		41	43	48	41	49	48	44

Sites 8 and 9 were mapped as badlands on the SCS soils map and is Holocene sheetwash alluvium in surficial geologic mapping done by the U.S. Geological Survey (Schneider and others, 1979). They are both sandy deposits. Site 8 is on the alluvial apron at the toe of steep slopes below the mesa, and site 9 is on a gentle slope below the mesa. Site 8 is coarse throughout the depth of sampling, but site 9 became finer abruptly at 2 meters depth.

Sites 13, 15, and 16 are the top, midslope, and base, respectively, of a dune. This dune lies near the edge of the mesa in an area mapped by the SCS as Doak-Avalon Association, but dunes such as this are probably inclusions of the Sheppard series.

All these soils have low specific surfaces as indicated by low moisture-retention capabilities and all have high void capacities near the surface (figs. H-2 and H-3). Therefore, infiltration is high and vegetation cover is relatively good, ranging from 40 to 50 percent. A water table exists at sites 1 and 2, which explains the dominance there of the phreatophyte, rubber rabbitbrush. Sites 9, 13, 15, and 16 have constrictions in the profiles within 1.4 meters of the surface. In the constricted zones, their void capacities (VMC) are less than moisture-retention capabilities (MRC) (fig. H-3). This restriction would slow drainage and make the draining moisture available to vegetation for a longer period of time. Site 8 shows no constriction in void capacity quite as low as MRC, but it is restricted to 11 molecular layers. This constriction is apparently sufficient to "perch" some soil moisture, which results in a cover consisting almost entirely of grasses (table H-1).

Flood plains

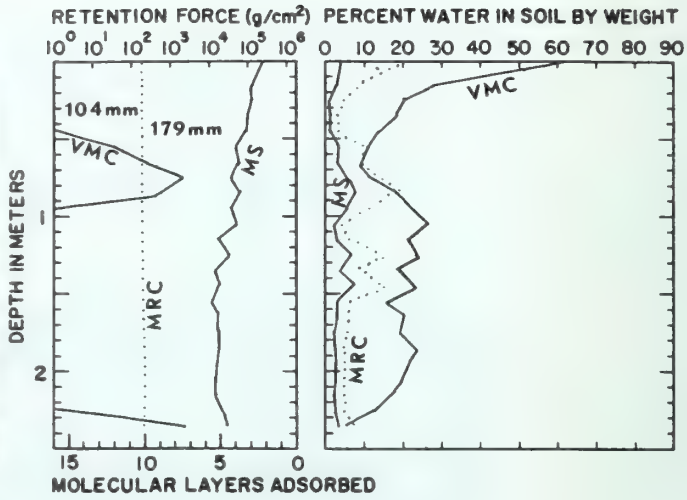
Sites 3, 4, 5, 6, and 7 are flood-plain sites and are mapped as aeolian sand on the geologic map and as Blancot-Notal Association on the SCS soils map. They are alluvial deposits, probably characteristic of the Notal series. Site 5 has some windblown sand on the surface.

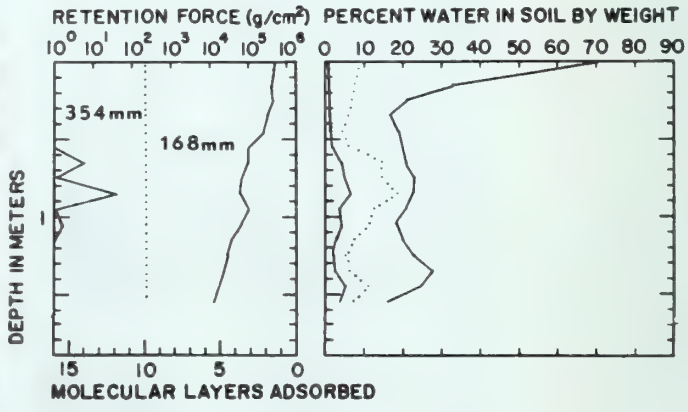
Sites 3, 4, and 5 are in a greasewood-alkali sacaton vegetation type (table H-2). Sites 6 and 7 are in an alkali sacaton type. Site 5 is by far the most productive of this group. It supports 36 percent live vegetation cover. Sites 3, 5, and 6 were selected to be representative of their respective vegetation types. Site 4 is a greasewood slick (pan spot) and site 7 is an alkali sacaton hummock.

Void capacity at site 4 is in excess of MRC throughout the depth of sampling (fig. H-4). This indicates that infiltration and drainage should be good. The MRC is somewhat variable but high enough to expect that some vegetation could be supported by the retained moisture. There is no vegetation whatsoever on this site. This may be due to a sodium deposit left by a greasewood plant which formerly occupied the site. In fact, the whole profile is similar to that of site 3 which currently supports live greasewood. There are greasewood slicks throughout the type characterized by site 3. These slicks lower the overall productivity of the type, but they are a product of the type itself. The

Table H-2. --Vegetation cover, in percent, at flood plains sites

Species		Site			
Latin name	Common name	3	4	5	6 and 7
Shrubs					
Artemisia sp.	Sagebrush	--	--	2	--
Chrysothamnus greenei	Greene's rabbitbrush	5	--	1	--
Opuntia polycantha	Plains pricklypear	--	--	1	--
Sarcobatus vermiculatus	Greasewood	5	--	7	--
Grasses					
Bouteloua eriopoda	Black grama	--	--	3	--
Festuca sp.	Fescue	1	--	--	--
Sporobolus airoides	Alkali sacaton	1	--	12	15
Forbs					
Salsola kali	Russian thistle	11	--	10	3
	Unidentified forbs	--	--	--	2
Mulch		1	--	--	--
Bare soil		76	100	64	80
Total live cover		23	0	36	20





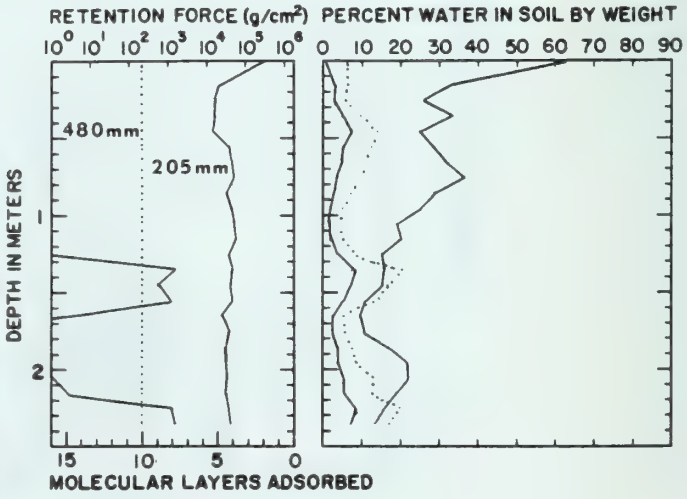


Figure H-4.--Moisture relations in soils for greasewood-alkali sacaton sites on flood plains.

profiles of VMC and MRC with depth (fig. H-4) indicate a higher productive potential for these sites than presently exists, owing to adverse effects caused by the greasewood bringing sodium salts to the surface.

Site 5 is a more productive site of the same vegetation type. This site has some loosely packed windblown sand over the alluvium, and consequently, the MRC at the surface is lower than at site 3. This causes the drainable void volume (VMC x VW−MRC x VW) to be greater (fig. H-4) allowing greater infiltration. In both sites there are drainage constrictions in the profiles at depths where MRC exceeds VMC. Fluctuations in MRC with depth are associated with sandy, wind-worked sediments alternating with finer-textured sediments deposited from streamflow. However, the constriction at site 5 is deeper in the profile and there is a larger capacity to store moisture above the constriction. This should provide more moisture for the vegetation.

Sites 6 and 7 (fig. H-5) support about the same amount of alkali sacaton as site 5, but the greasewood is absent. Their profiles indicate that their surface void capacities are less than that at site 5, but there are no drainage constrictions.

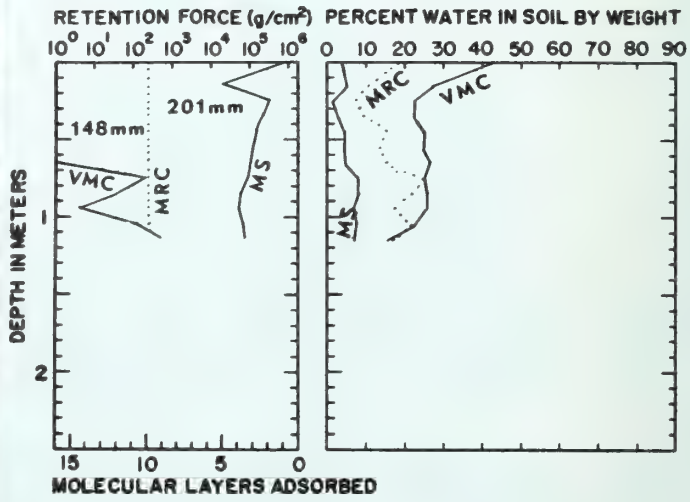
Mesas

All four of the sites in this group are in an area mapped as the Doak-Avalon Association. Sites 10 and 11 are probably the Doak series. Sites 20 and 21 are probably inclusions of the Shiprock series. Of these four sites, site 20 has the most grass cover and the least barren ground, whereas the converse is true for site 10 (see fig. H-6 and table H-3). Sites 11 and 21 are intermediate in this respect. Sites 10 and 20 represent the galleta type while site 11 is galleta and big sagebrush. Site 21 supports galleta and Greene's rabbitbrush.

Amounts of void in all four surface soils appear to be great enough that infiltration rates would be high. Site 21 is the best drained, and the only one that has a significant drainage restriction is site 20. Site 20 had the most cover of all 21 sites sampled on the study area. Site 10 is the same vegetation type but had less than one-half the cover. This difference may be due, in part, to differences in grazing. Probably, the most important difference between the two sites is that the soil at site 20 becomes finer textured below 0.8 m, and drainage is severely constricted at 1 m depth (fig. H-6). This constriction is much more effective in perching water than the relatively minor constriction at 1.3 m in the soil at site 10 where the soil becomes coarser. Sites 11 and 21 are both more uniform in texture and their cover is intermediate to sites 10 and 20.

Slopes

Sites 17, 18, and 19 are located on or near contacts of the Fruitland Formation, Kirtland Shale, and Holocene alluvium (Schneider and others, 1979), and the area is designated Huerfano-Muff-Uffen complex on the SCS soils map. This area is a north-facing slope below a mesa and down toward barren alluvial flats. Sites 17 and 18 are probably the Muff series. Site 19 lies on nearly flat ground nearby and is probably the Huerfano series.



SITE 7

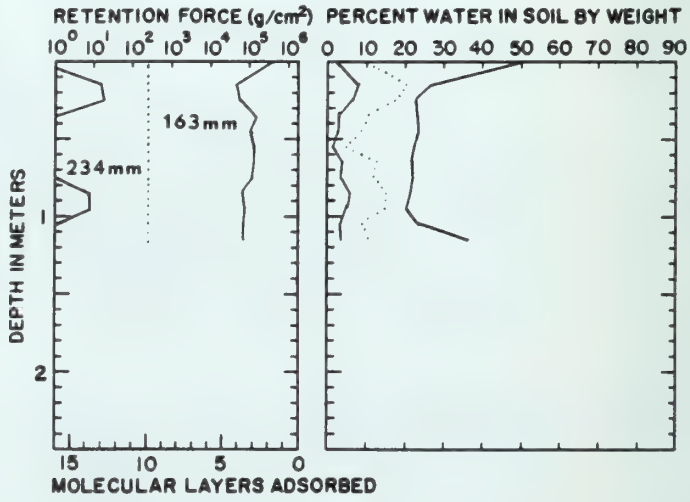


Figure H-5.--Moisture relations in soils for alkali sacaton sites on flood plains. Site 6 was in a barren interspace, and site 7 was in the alkali sacaton hummock where the man is working.

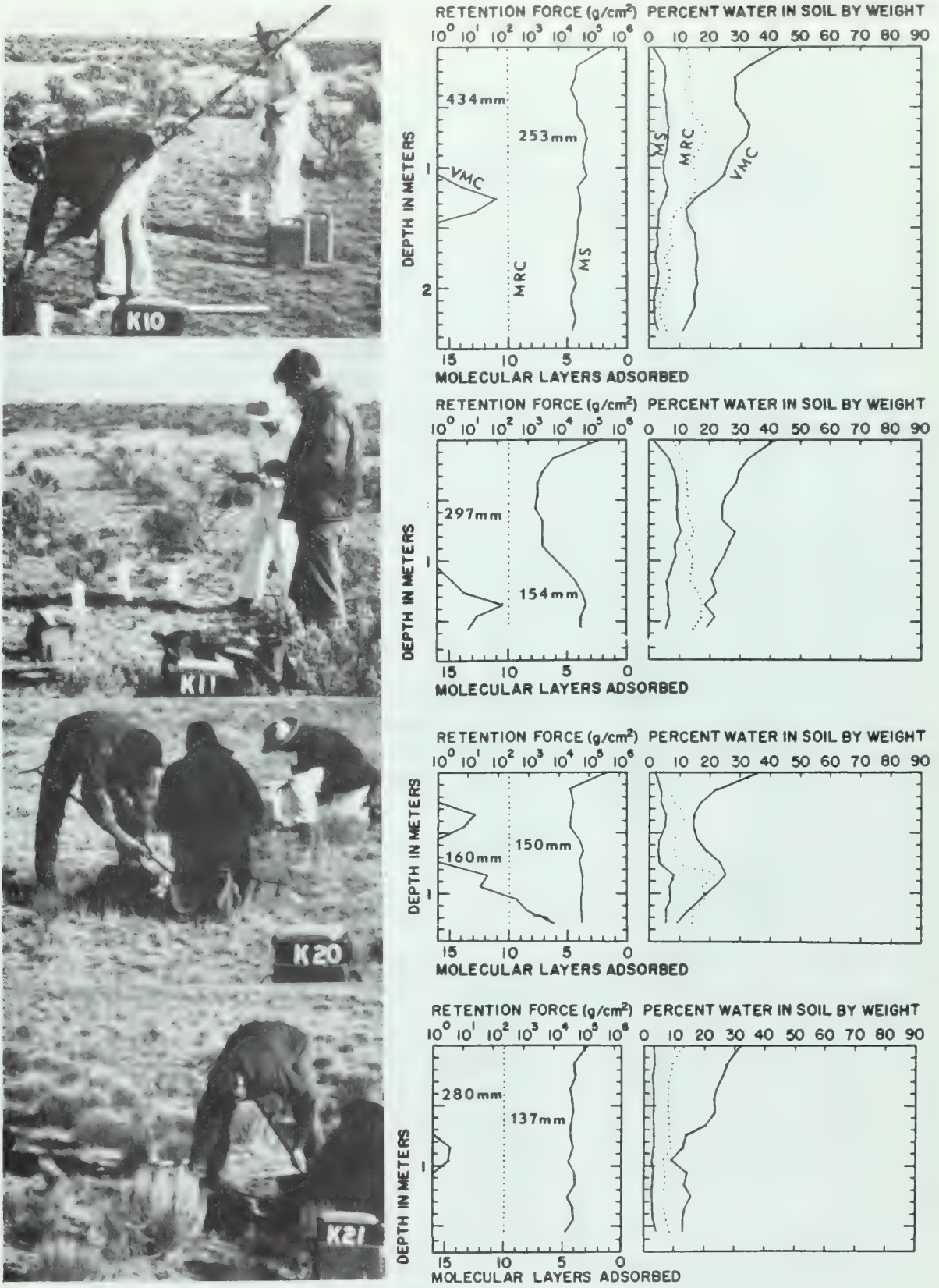


Figure H-6.--Moisture relations in soils for sites on mesas.

Table H-3. --Vegetation cover, in percent, at mesa sites

Species		Site			
Latin name	Common name	10	11	20	21
Shrubs					
Artemisia tridentata	Big sagebrush	3	8	--	--
Chrysothamnus greenei	Greene's rabbitbrush	--	--	4	15
Gutierrezia sarothrae	Broom snakeweed	--	--	--	3
Opuntia polycantha	Plains pricklypear	--	--	1	--
Grasses					
Bouteloua eriopoda	Black grama	1	5	7	7
Hilaria jamesii	Galleta	18	26	37	16
Forbs					
Salsola kali	Russian thistle	--	--	10	3
	Unidentified forbs	2	4	2	--
Mulch		--	--	--	--
Bare soil		76	57	39	56
Total live cover		24	43	61	44

Site 18 has the most cover, which is mostly grass (table H-4). It has a large VMC throughout the depth of sampling (fig. H-7). At site 17, which supports both grasses and shrubs, the VMC of the surface soil is large, but the MRC exceeds VMC at 50 cm depth. Site 19 supports only saltbush and has very little voids for storage of water. MRC exceeds VMC at a depth of only 30 cm.

Badlands and Blowout

Site 12 lies at the upper boundary of a badlands area (SCS mapping designation). It is 80 percent barren and 20 percent rock and lichen-covered. Site 14 is located in a blowout area of a nearby dune. It has 37 percent live vegetation cover (table H-5). Both sites lie in an area designated Kirtland Shale on the geologic map (Schneider and others, 1979). The upper 15 cm of site 14 differs from site 12, but below 15 cm site 14 is similar to site 12; however, the soil is not quite as fine textured.

Site 12 is barren, mostly because only a small amount of water penetrates the surface. The combination of extremely fine-textured material and low void space (fig. H-8) means that whatever moisture enters is held to the soil particles with a large retention force. Vegetation is unable to desorb it. On the other hand, site 14 shows that a small amount of void space at the surface exceeding MRC allows some water to infiltrate, but it is held in the upper part of the profile because of underlying constrictions in the void space. The contrast in vegetation demonstrates the effect of a layer of coarser material with adequate void space on top of finer material. A small increase in void space in the upper 15 cm causes a tremendous increase in vegetation cover.

Summary and Conclusions

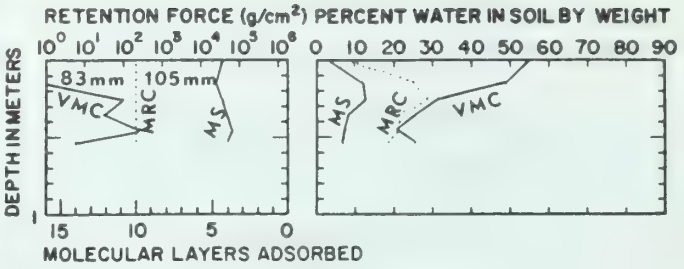
The sites with the most cover are generally either underlain by a water table at shallow depths, or are sandy dunes, mesas, or gentle slopes.

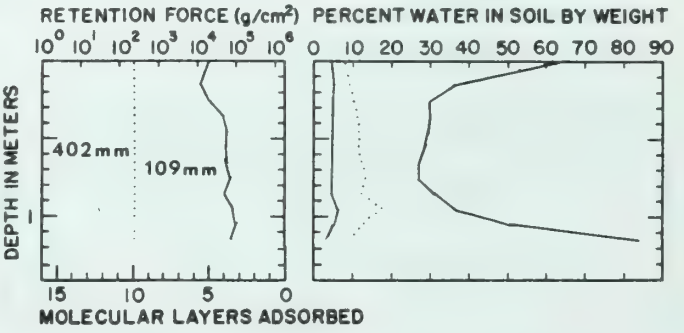
The dunes sites, as a group, had the most live cover of all the groups sampled. All the dunes sites had between 41 and 49 percent live cover. The dunes adjacent to Kimbeto Wash were underlain by a water table as indicated by the phreatophyte rubber rabbitbrush. Alkali sacaton was the dominant grass on those sites. The upland dunes were not underlain by shallow water tables. Important species on upland dunes were big sagebrush, shadscale, Greene's rabbitbrush, black grama, galleta, ring muhly, and alkali sacaton. The uplands dunes sites all have constrictions in their profiles which make the draining moisture available to plants for a longer period of time.

The flood-plains sites, as a group, have the least live cover of all the groups sampled. Grasses are less vigorous on these sites, probably, for several reasons. Some of the soils are fine textured causing runoff to be excessive and available soil moisture to be low. Some of the soils appear to be sodic and most are probably saline. Also, grazing pressure may be more intense because of its proximity to Kimbeto Wash and to a well.

Table H-4. --Vegetation cover, in percent, on slope sites

Species		Site		
Latin name	Common name	17	18	19
Shrubs				
Atriplex confertifolia	Shadscale	17	--	--
Atriplex obovata	Broadscale saltbush	--	--	28
Grasses				
Hilaria jamesii	Galleta	6	22	--
Sporobolus airoides	Alkali sacaton	12	20	1
Forbs				
Salsola kali	Russian thistle	3	1	--
	Unidentified forbs	--	--	1
Mulch		--	--	--
Bare soil		22	49	47
Rock		40	8	23
Total live cover		38	43	30





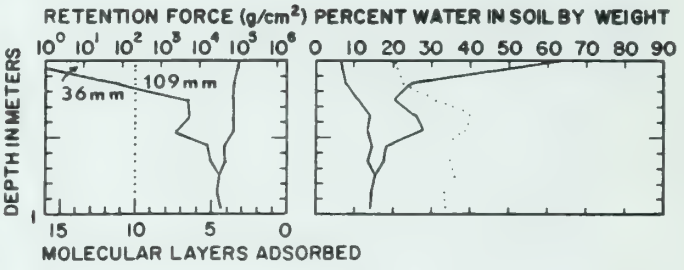
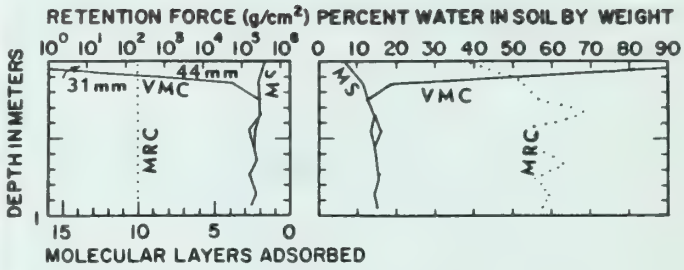


Figure H-7.--Moisture relations in soils on slopes. Site 17 has a residual soil; sites 18 and 19 have alluvial soils.

Table H-5.--Vegetation cover, in percent, on badland and blowout sites

Species		Site	
Latin name	Common name	12	14
Shrubs			
Atriplex obovata	Broadscale saltbush	--	9
Grasses			
Sporobolus airoides	Alkali sacaton	--	28
Lichen	Lichen	11	--
Mulch		--	--
Bare soil		80	61
Rock		9	2
Total live cover		11	37



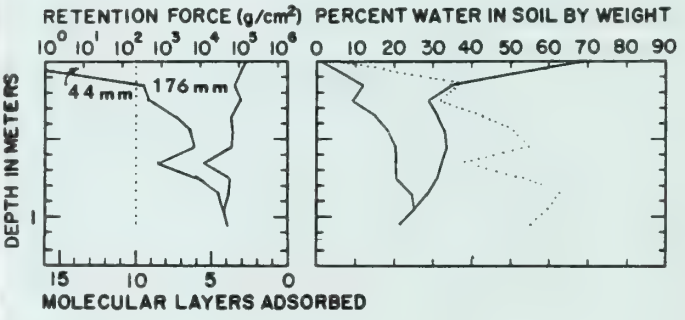

RETENTION FORCE (g/cm²)
PERCENT WATER IN SOIL BY WEIGHT
10⁰ 10¹ 10² 10³ 10⁴ 10⁵ 10⁶
0 10 20 30 40 50 60 70 80 90
DEPTH IN METERS
1
44 mm
176 mm
15 10 5 0
MOLECULAR LAYERS ADSORBED

Figure H-8.--Moisture relations in soils for a badland site on a bentonite bed (upper photo), and for a nearby site with a fine-textured soil in a blowout.

The sites which are close to Kimbeto Wash are underlain by a water table and support greasewood and alkali sacaton. Moisture-retention capabilities are low and void space is high in the surface soils. Drainage is impeded below 0.5 m in most of the profiles. The sodium deposits on the surface of the pan-spot site blocks infiltration and prevents vegetation growth. The sites farther from the Wash support mainly alkali sacaton, as the water table is too deep to support greasewood. The moisture-retention capabilities are higher than for the sites close to Kimbeto Wash and amounts of void space are variable. The cover is sparse.

The mesa sites are characterized by big sagebrush, Greene's rabbitbrush, black grama, and galleta. They have almost as much live cover as the dunes sites. Moisture-retention capabilities tend to be low and void capacities are moderate.

The residual soil sampled on a slope supported shadscale, galleta, and alkali sacaton. The moisture-retention capability was high and a drainage constriction occurred within one-half meter of the surface. The live cover was 38 percent. One of the alluvial (transported) soils on a toe slope was very sandy and permeable, and had 42 percent cover of galleta and alkali sacaton. The other alluvial soil was on a gentle slope, but the soil was finer textured and essentially impermeable below 0.2 m. This site was sparsely covered with broadscale saltbush.

The badlands soil sampled was highly bentonitic. Moisture-retention capability was very high and the void space was extremely low, except for the surface 0.1 m. The soil appears to be impermeable below 0.2 m. Ten percent cover by lichen was the only vegetation on the site. The immediate surface soil at the blowout site was permeable, but drainage is severely restricted in the fine-textured soil below 0.2 m. Nonetheless, there was 37 percent cover of alkali sacaton and broadscale saltbush.

Vegetation cover on all sites is dependent on moisture. If a site is not underlain by a water table at a shallow depth, it must receive moisture by infiltration. The ideal conditions for infiltration and efficient moisture storage are large void capacities at the surface and then a constriction in void capacity (compacted layer) 0.5 to 0.75 m below, to hold the moisture where the vegetation can use it. It is desirable to have finer-textured (high moisture-retention capability) soil at depth to hold more moisture and coarser-textured (low moisture-retention capability) soil at the surface to reduce evaporation as well as facilitate infiltration. Mulching with rock or vegetation material will be needed to stabilize the coarse-textured surface material during rehabilitation if the area is mined.

Table H-6

CONVERSION FACTORS

S. I.	Multiply by	Customary
mm (millimeters)	.03937	inches (in.)
m (meters)	39.37	inches (in.)
g/cm^3, g/cc (grams per cubic centimeter	62.43	pounds per cubic foot (lb/ft^3)
g/cm^2 (grams per square centimeter)	.01422	pounds per square inch (psi)
	9.678×10^{-4}	atmospheres (atm)
	9.806×10^{-4}	bars
log (grams per square centimeter)	1.0	pF

SECTION I

SEDIMENT YIELDS

SECTION I

SEDIMENT YIELDS

The sediment yield values presented for this area were derived using a numerical rating method developed by the Pacific Southwest Inter-Agency Committee (PSIAC) (1968). They have been judged to be reasonably accurate, but they have been only partially verified by field measurements.

The mapping units that are the basis of this evaluation are sediment-source areas. A source area is a small drainage area occurring on a single landform type or an inseparable complex of landforms and usually is only part of a complete drainage basin. The PSIAC method is used to assess the hydrologic variation of the given landforms as well as to make estimates of sediment yield from them. Numerical ratings are assigned for each of the nine factors of the PSIAC method to representative sediment-source areas in accordance with the degree of influence each factor has on the sediment yield from the area. These nine factors are surface geology, soils, climate, runoff, topography, ground cover, land use, upland erosion, and channel erosion and sediment transport. The method was developed to make broad sediment-yield classifications for large areas such as river subbasins, but Shown (1970) found that the method provides reasonable estimates for small drainage basins (.02—7.5 mi^2). In applying the method on source areas, some adjustments are made because a complete drainage system is not being considered. Alluvial-fan and flood-plain development are not considered in the topography factor, and sediment-transport capabilities are not considered for channels that originate in upslope source areas and that cross through the source area being rated. These factors are taken into account later when making estimates of sediment discharge from drainage basins.

Interpretations of aerial photographs (1:32,000 scale) were used to extend the source-area sediment-yield estimates for representative source areas in each landform type to the whole area. This was accomplished with a stereo plotter and resulted in the source-area sediment-yield map shown in figure I-1. The slope data shown in figure I-1 were obtained from the 1:24,000 USGS topographic quadrangles. Bare-soil data were extrapolated from measurements made at about 30 sites in the study area. Those measurements are listed in the Vegetation and Soil-Moisture Relationships sections of this report. The moisture-retention capabilities of the soil materials were extrapolated from the data presented in the Soil-Moisture Relationships section.

The complete main-channel system was classified and mapped according to channel type and condition (fig. I-2) to aid in assessing channel erosion and sediment transport. The channel classification was done by interpretation of the aerial photography, and only those channels that were larger than third or fourth order according to Strahler's (1952) classification were delineated.

Sediment accumulation was measured in two stock-water ponds in the area by probing the deposits with a pointed one-half inch diameter steel rod from a boat. The resulting sediment volumes were divided by the respective drainage areas above the pond and by the ages, in years, of the ponds to obtain average annual estimates of sediment accumulation (see table I-1).

Table I-1.--*Sediment accumulations in stock ponds*

Pond	Age (yrs)	Drainage area (mi^2)	Sediment accumulation (acre-ft)	Sediment accumulation (acre-ft/mi^2/yr)
A	16	0.89	1.31	.09
E	42	0.40	1.98	.12

Estimates of average annual sediment discharge for basins B, C, and D (fig. I-2) were made by applying sediment-conveyance factors to the area-weighted average source-area sediment yields. The sediment-conveyance factor represents that proportion of sediment that is yielded from one source area and not left stranded on another source area, plus sediment that is conveyed through main channels and principal tributaries and not deposited in the channels or on alluvial plains or fans. The method reported by Frickel and others (1975) was used to estimate the sediment-conveyance factors. The analyses of channel conditions shown in table I-2 were used in applying that method.

Table I-2.--*Analyses of channel classification for drainage basins (percent of total channel length)*

Basin	Raw gully	Healed gully	Braided or aggrading	Ungullied
A	0	10	10	80
B	90	10	--	--
C	65	11	13	11
D	6	40	40	14
E	6	70	--	24

Source-Area Sediment Yields

Source-area sediment yields on the study area range from low to high as indicated in figure I-1. The main interacting factors causing the variation in sediment yields are: (1) Different slope gradients,

EXPLANATION

Estimated source-area sediment yields (acre-ft/mi²/yr)		Landform(s)	Slope gradients (percent) Range	Slope gradients (percent) Mean	Estimated bare soil (percent) Range	Estimated bare soil (percent) Mean	Estimated soil-moisture retention capability (percent) Range	Estimated soil-moisture retention capability (percent) Mean
0-.1	Low	Wide channel	0-1	1	100	100	2	2
		Riparian dunes	0-4	2.6	52-77	62	2-20	8
0-.2		Mesa with dunes	1-6	3.0	39-76	56	2-15	8
		Low dunes on alluvial plain	1-8	1.3	46-58	55	7	7
.21-.4		Alluvial plain with dunes	1-24	4.6	64-80	72	9-20	14
		Hillslope	10	10	22-49	39	5	5
.41-.65	Moderate	Hillslope	5-18	10.6	59-77	68	10 (stony)	10
		Dissected alluvial fan	1	1	80	80	35	35
.66-1.1		Alluvial plain	1-5	1.3	61-90	75	20	20
		Hillslope	2-17	6.9	74	74	10 (stony)	10
1.5-2.5	High	Badland	3-17	8.4	89	89	——	——
2.51-4.0		Badland	6-22	9.6	80	80	8-40	35
4.01-6.0		Badland	5-80	16.5	61-88	79	8-40	35

Base from U.S. Geological Survey
Kimbeto, Pueblo Bonito, Pueblo
Bonito NW and Sargent Ranch
7½-minute quadrangles

SOURCE-AREA SEDIMENT YIELDS FOR THE KIMBETO WASH EMRIA STUDY AREA, NEW MEXICO--1976

FIG. I-1

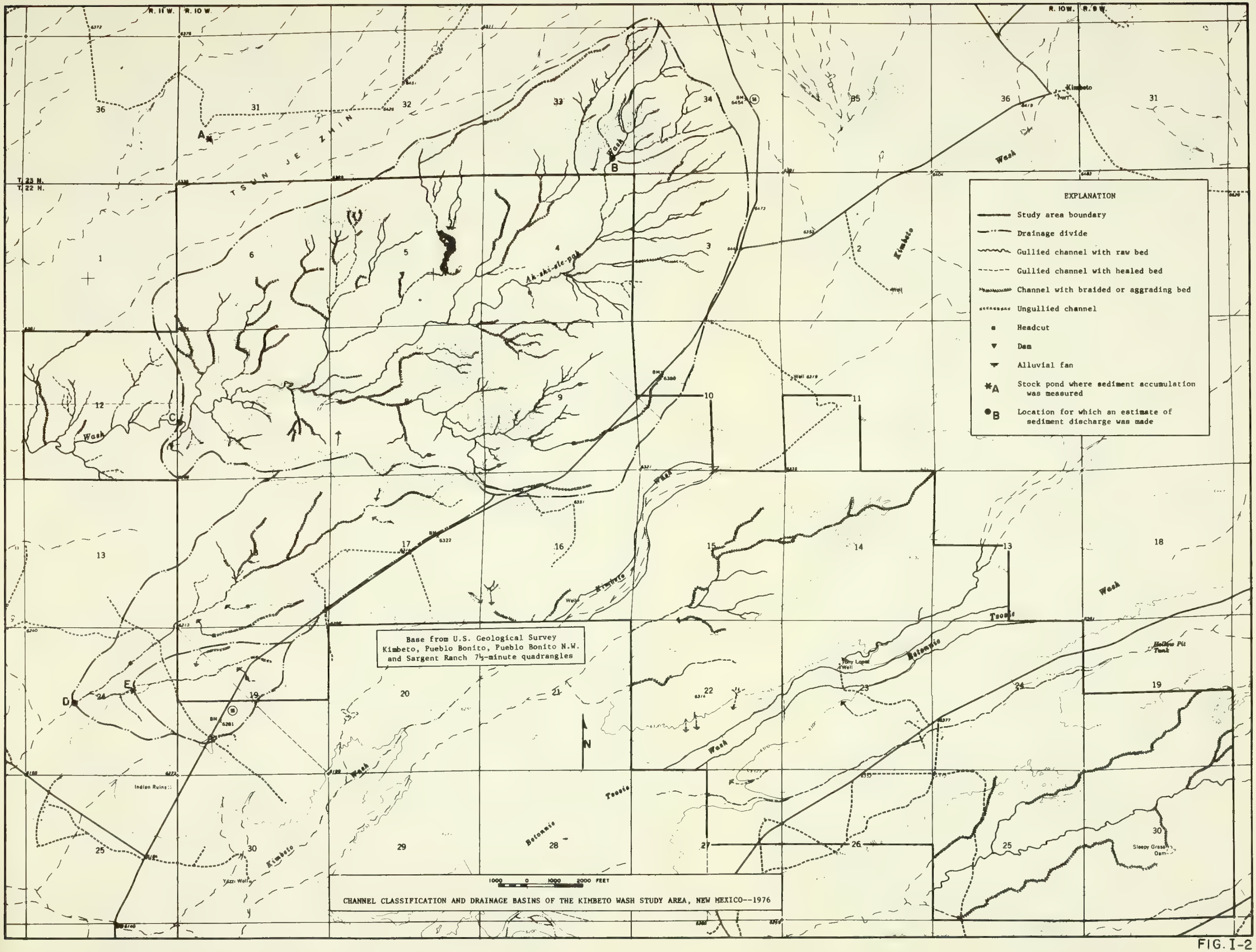

R. 11 W.
R. 10 W.
R. 10 W.
R. 9 W.
T. 23 N.
T. 22 N.
TSUN JE ZHIN
Ah-shi-sle-pah
Wash
Kimbeto
Tsosie
Botonnie
Tsaile
Hollow Pit Tank
Sleepy Grass Dam
Indian Ruins
Tony Lopez Well
Well
A
B
C
D
E
EXPLANATION
Study area boundary
Drainage divide
Gullied channel with raw bed
Gullied channel with healed bed
Channel with braided or aggrading bed
Ungullied channel
Headcut
Dam
Alluvial fan
Stock pond where sediment accumulation was measured
Location for which an estimate of sediment discharge was made
Base from U.S. Geological Survey
Kimbeto, Pueblo Bonito, Pueblo Bonito N.W.
and Sargent Ranch 7½-minute quadrangles
N
1000 0 1000 2000 FEET
CHANNEL CLASSIFICATION AND DRAINAGE BASINS OF THE KIMBETO WASH STUDY AREA, NEW MEXICO--1976

FIG. I-2

(2) different kinds of surficial geologic materials, and (3) the amount of vegetative cover associated with the different materials. The data in the explanation table in figure I-1 shows that, in general, the source-area sediment yields increase with increases in the slope gradients, in the moisture-retention capabilities of the soils, and in the amounts of bare soil. Regression equations defining the relationship of sediment yield to these factors probably would not be too valid because of the variability of the factors within each of the sediment-yield categories.

Low source-area sediment yields shown in figure I-1 occur from the flat to moderately sloping mesas, and from valley-situated alluvial plains and active riparian dunes which, in general, are covered with coarse-textured soils or sands which are very permeable. Fine-textured soils, sparsely covered with vegetation, are interspersed with low, flat, wind-lain sand deposits on the alluvial plains. These fine-textured soils are very slowly permeable because they are dispersed, and are resistant to erosion because they are compacted and cohesive. The plains function mainly as surfaces of transport for sediment derived from the badland areas upstream. Most of the sediment produced from sandy areas resulted from materials deposited in the channels by winds. Subsequent flows clear these wind-laid deposits from the channels.

Moderate sediment yields occur from rilled or gullied alluvial fans and plains and from moderately steep hillslopes. These moderately yielding areas, in general, are not mantled with sandy materials.

The relatively barren badlands all yield sediment at high rates. The rates are highest in the areas that have the most relief. The lower value of each yield range for the three badland categories shown in figure I-1 represents those parts of the badlands consisting of exposures of buff-colored bentonite. The bentonite is very cohesive and, thus, more resistant to erosion than other strata in the badlands.

Channel erosion is significant on much of the study area, as can be inferred from the amount of channel length that is classified as raw gully (fig. I-2). There is practically no erosion at present in ungullied channels, and little erosion in those channel reaches classified as aggrading or braided where some sediment is being deposited. Only the largest headcuts in the area are indicated in figure I-2. Most of the headcuts appear to advance only a few feet a year and are, therefore, insignificant sources of sediment. There was no indirect method for evaluating the amount of sediment yielded from the channels of Kimbeto and Betonnie Tsosie Washes because material scoured from the beds and cut from the banks during flow peaks is replaced by sediment deposited on the bed and on point bars during the recession of the flows.

The sediment yields shown for the wide channels in figure I-1 represent small net changes in the volume of unstable alluvium associated with the channels. The yields do not account for the "stepwise" movement of unstable alluvium downstream during each flow. Scour-depth data would be needed to evaluate the amount of alluvium transported from a reach during a flow.

Sediment Discharge from Drainage Basins

Two stock ponds in the area were surveyed to determine long-term sediment discharge from the drainage basins above the ponds. The two basins, designated A and E in figure I-2, are on sand-mantled mesas; therefore, sediment discharge from them is low, as shown in table I-1.

Sediment discharge was estimated for three other basins in the study area (see fig. I-2 and table I-3). Sediment discharge from basin B

Table I-3.--*Estimated annual sediment discharge from drainage basins*

Basin	Drainage area (mi^2)	Weighted source-area sediment yield (acre-ft/mi^2/yr)	Estimated sediment conveyance factor	Estimated sediment discharge (acre-ft/mi^2/yr)
B	.44	1.8 −2.9	.9	1.6 −2.6
C	8.2	1.9 −2.9	.8	1.5 −2.3
D	2.2	.12− .31	.4	.05− .12

is high owing to high source-area yields and to the large percentage of raw gullied channels. Because the basin is relatively small (0.44 mi^2) and steep, there is a lack of bottomland areas and low-gradient channels where sediment might be deposited. Sediment discharge from basin C is also high even though it is a much larger basin (8.2 mi^2). This sediment discharge is again caused by high source-area sediment yields and because about 65 percent of the channels exist as gullies with raw beds. Most of the sediment in the flows is fine textured and, apparently, very little sediment is deposited anywhere in this badland basin. Sediment discharge from basin D is low because it is relatively flat, sand-mantled and, thus, is a relatively permeable basin similar to the two basins where the ponds were surveyed. Basin D also has the lowest sediment-conveyance factor of all the basins considered. The value of 0.4 indicates that about 60 percent [(1 −0.4) 100] of the sediment moving off source areas is deposited where slope gradients decrease or in the main channel and principal tributaries.

All of these sediment-discharge values are in accordance with expected values for these types of watersheds in the arid southwestern United States.

Effects of Mining

Without reference to a specific mining plan, it is difficult to assess the effects of mining on sediment yield. Nonetheless, if the area is mined, it is assumed that the area will be rehabilitated for livestock production and wildlife habitat. It is also assumed that the maximum depth of mining

would be 200 feet, and that only those areas with more than 4 feet of coal within 200 feet of the land surface would be mined. Cognizance is given to the Federal regulations that there are severe limitations on the discharge of suspended solids from mining areas regardless of what the discharge was prior to mining. Erosion-control measures will be necessary to prevent an increase in sediment yield from the area following mining.

Extremely important hydrologic implications exist with respect to mining across Kimbeto, Betonnie Tsosie, and Ah-shi-sle-pah Washes. In this evaluation it was assumed that Kimbeto and Betonnie Tsosie Washes would not be mined across because of the large magnitude of some flows in them. Mining across Ah-shi-sle-pah Wash seems to be more likely because of the extent of the coal resource there and because of the smaller size of the wash and sizes of flows. Mining across Ah-shi-sle-pah Wash could be done if flows were routed through diversion channels near the foot of the badland slopes both to the north and south of the wash. These diversion channels likely would be necessary anyway to intercept flows from the badlands that would otherwise flood the mine. These channels would have to be lined to prevent bed and bank erosion which, if allowed to occur, would increase sediment discharge from the area. Structures would be necessary at confluences of tributaries with the diversion channels to maintain local base levels so that downcutting of tributaries would be prevented.

Another question to be addressed would be whether or not to design and maintain the diversion channels as permanent stream routes. Adopting such a plan would likely be more economical and result in less erosion than designing the reclaimed topography to include channels that would carry flows arising upstream from the mined areas.

If the lower part of a badland scarp is mined, the whole scarp from top to bottom should be mined and reclaimed. If only the lower part of the scarp is mined, flows from upslope would probably severely erode drainageways across the mined area for several years after the sloping landscape has been reshaped. Valleys or drainageways in the shaped topography following mining should have broad, laterally flat bottoms in order to minimize channel erosion.

The opportunity exists during reclamation for increasing the vegetal cover and reducing erosion of the badlands and the fine-textured areas within the alluvial plains. This would require transferring sandy soil material from the mesas and/or riparian dunes to the badland areas (see fig. I-1) for use as topping over the graded spoil. Naturally occurring examples of good vegetal cover and little erosion on moderately sloping areas mantled with sandy material exist in the north-central and the southeastern part of section 16, T. 22 N., R. 10 W.

Differential settling of spoils after grading results in some depressions which retain water that would otherwise run off and cause rill and gully erosion of slopes. However, mechanical treatment, such as contour furrowing (Branson and others, 1966), would be needed to reduce excessive runoff and erosion and enhance vegetation on any mined areas that will

not be topped with sandy material. Very little runoff or erosion will be expected to occur from areas topped with sandy material even without mechanical treatment.

The geologic logs in section N of this report show that only at drill hole DH-6 is there an indication that the land surface would be lowered after mining and reclamation. This is based on the assumption that the 154 feet of overburden would bulk 25 percent to give 192.5 feet of spoil to fill a 200-foot excavation after 46 feet of coal is removed. That land surface could be lowered perhaps as much as 10 feet more from the removal of much of the sandy material for use as growth media elsewhere. The resulting depression of 17.5 feet ($200 - 192 + 10 = 17.5$) would not seem to be a significant problem because it would be located on a mesa where there are only small amounts of runoff and streamflow.

Sedimentation ponds will be necessary to intercept the runoff from unreclaimed spoil areas, haul roads, coal-handling and equipment-maintenance areas to prevent increased sediment discharges downstream.

Implementation of the erosion-control practices discussed in this section, which are based on State and Federal surface-mining regulations, should result in no increase in sediment yield from the area because of mining. In fact, there is a moderate chance that mining and reclamation would reduce the high sediment contributions of areas consisting of fine-textured, poorly permeable materials.

SECTION J

HYDROLOGY AND WATER SUPPLY

SECTION J

HYDROLOGY AND WATER SUPPLY

Surface Water

Quantity. The streams in the Kimbeto EMRIA study area are ephemeral; that is, flow occurs only in direct response to storm runoff. Much of the surface runoff occurs during July through September as a result of localized, high-intensity rainfall from thunderstorms of short duration. Table S-1 (in section S) is a tabulation of average monthly and annual runoff volumes from Ah-shi-sle-pah Wash in the Kimbeto study area and three washes in the vicinity of the study area. The streamflow-gaging site on Ah-shi-sle-pah Wash in shown in figure S-1. The drainage basins of the gaging sites in the vicinity of the study area are representative of the topographic, topsoil, vegetative, and climatic characteristics of the Kimbeto EMRIA study site. The centroids of these drainage basins located with respect to the study area are as follow: Hunter Wash - 21 miles northwest, De-na-zin Wash - 14 miles northwest, and Chaco Wash - 20 miles southeast.

The highest runoff in the Kimbeto EMRIA study area are produced from the badlands. The badlands in the study area are unconsolidated shale outcrops; the shale outcrops erode readily when they are subjected to surface runoff. The drainage basin upstream from the streamflow-gaging station on Ah-shi-sle-pah is about 85 percent badlands compared to about 40 percent in the study area. The average yield from this basin was 122 acre-feet per square mile per year (acre-ft/mi^2/yr) during 1977-78. The badlands within the drainage basins upstream from the streamflow-gaging stations on Hunter Wash, De-na-zin Wash, and Chaco Wash are estimated to comprise 40 percent, 30 percent, and 5 percent of the respective drainage areas. The annual unit runoffs from these basins, based upon the short period of streamflow records available, are calculated to be 13.9, 15.7, and 3.73 acre-ft/mi^2/yr respectively. Unit runoff usually decreases as the size of the drainage area increases, all other factors being equal. These short-term records may not be statistically representative of long-term averages.

The runoff from Kimbeto Wash and Betonnie Tsosie Wash, the other two major streams in the Kimbeto EMRIA study area, are estimated to be 500 acre-feet per year (acre-ft/yr) from Kimbeto Wash and 300 acre-ft/yr from Betonnie Tsosie Wash, based on percentages of badlands drained. The drainage area of the Kimbeto Wash watershed is about 65 square miles (mi^2) of which 20 percent is estimated to be badlands, and the drainage area of the Betonnie Tsosie Wash watershed is about 45 mi^2 of which 15 percent is estimated to be badlands.

The ephemeral flow-duration characteristics at the streamflow-gaging stations on Hunter, De-na-zin, and Chaco Washes are very similar to

those of Ah-shi-sle-pah Wash in the Kimbeto EMRIA study area. The duration of flow from a single thunderstorm has lasted from 2 to 24 hours while diurnal flow from melting snow has lasted up to two weeks at the Ah-shi-sle-pah Wash gaging station. The duration of runoff is as short as several hours for thunderstorms to as long as several weeks for snow melt.

Kimbeto Wash and Betonnie Tsosie Wash in the study area do not flow about 90 percent of the time. The longest period with no flow at the Ah-shi-sle-pah gaging station during 1977-78 was 94 consecutive days. Longer periods of no flow are probable with weather conditions more arid than 1977-78.

The flood-frequency discharge estimates in cubic feet per second (ft^3/s) for the three major streams at the gaging station in the Kimbeto study are given in table J-1.

Table J-1.--Flood-frequency discharge estimates of major streams in the Kimbeto EMRIA study area.

Stream name	Drainage area (mi^2)	Flood-frequency discharge					
		2-year (ft^3/s)	5-year (ft^3/s)	10-year (ft^3/s)	25-year (ft^3/s)	50-year (ft^3/s)	100-year (ft^3/s)
Ah-shi-sle-pah Wash	8.2	270	660	1,000	1,600	2,100	2,800
Betonnie Tsosie Wash	45	800	1,600	2,500	4,200	6,000	8,000
Kimbeto Wash	65	900	1,900	3,000	4,800	7,000	9,000

The flood-frequency discharge estimates for Ah-shi-sle-pah Wash were determined from correlations using channel-geometry measurements (Scott and Kunkler, 1976). The peak discharge during 1977-78 was 1,200 ft^3/s at the Ah-shi-sle-pah Wash gaging station. The correlations for determining flood-frequency discharges by channel-geometry measurements have not been extended to include streams with wide alluvial channels such as those of Kimbeto Wash and Betonnie Tsosie Wash. Flood discharges on these washes were estimated on the basis of gaged sites with similar watershed characteristics and drainage sizes in the San Juan basin.

Chemical Quality. Chemical quality of the surface waters at or near the Kimbeto study area is shown in table S-3 for major chemical

and physical parameters, and table S-4 for trace element values. The suite of parameters include major dissolved ions, nutrients, organic carbon, heavy metals, and radiochemicals.

The principal water-quality data-collection site for the Kimbeto study area was at the Ah-shi-sle-pah Wash streamflow-gaging station. Miscellaneous samples were collected and analyzed from Tsosie Swale and escavado Wash. Data from nearby stations on the Chaco Wash, De-na-zin Wash, and Hunter Wash also were listed for comparison purposes. All of the samples were captured from ephemeral flows.

The samples were collected in the field using prescribed U.S. Geological Survey methods when flows were found in the channels. Samples were also analyzed that were collected by use of single-stage samplers or automatic pump samplers. The use of these sampling devices was adopted due to the unpredictability of flows in these channels and the inaccessibility to these sites during and immediately after rainstorms or snowstorms. These samplers captured samples that represented the rising stage of flow events. Certain constituents in the samples captured by the samplers may have changed before field retrieval, but care was exercised to select for analysis those constituents whose concentrations would exhibit very little or no change between the time of collection and time of analyses.

The dissolved-solids concentration of the surface water in this area is generally 500 milligrams per liter (mg/L) with the predominate ions being sodium, sulfate, and bicarbonate. The surface waters have low hardness because calcium and magnesium concentrations are low. The high bicarbonate would render the water's low hardness a carbonate or temporary hardness. The high bicarbonate also gives the water a high acid-buffering capacity.

The pH range of the surface waters is usually between 7.5 and 8.5, which is within the upper part of the range found for most natural streamflows. Concentrations of trace elements in the dissolved phase were either very low or below detection limits. However, total trace element concentrations were found to be high because of the usually high suspended-sediment concentration in the flows. A "total" concentration of a chemical constituent is the sum of the concentrations in the dissolved phase plus desorbed or extracted constituents from the surfaces of suspended sediment. The constituents are desorbed from the surfaces of sediment particles in the laboratory by a prescribed acidifying and heating treatment of the sample.

In general, the dissolved concentrations of trace elements were found to be only a very small fraction of the total concentrations; however, some of the constituents known to be more soluble, such as boron, lithium, and strontium, were found in high concentrations in some samples. The total concentrations were orders of magnitude higher than the dissolved concentrations for iron, manganese, barium, arsenic, lead, and chromium; this relation was especially the case for the first three elements.

Radiochemical constituents in the dissolved phase were found to be low but, as with the other trace elements, much higher levels of radiochemicals were found in the suspended-solid phase.

Suspended Sediment. The Ah-shi-sle-pah watershed upstream from the gaging station has a border of steep badlands around most of the basin. The steep badlands are abruptly bordered by a mild alluvial slope at the base. The alluvial slope from the base of the steep badlands to the nearest channel is formed by sediment deposited during runoff from the badlands and serves as a transport surface. This material is often referred to as badland outwash. The relatively flat outwash surface is crossed by small channels 1 to 3 feet deep that feed a few incised channels 3 to 15 feet deep. The deep incised channels show some evidence of bank erosion on the outside of bends, with berming taking place on the inside of bends; the channels appear to be degrading slowly. A high percentage (60% to 80%) of the outwash areas are covered with eolian deposits and in those areas produce little or no runoff. The only appreciable erosion from these eolian deposits due to runoff occurs where new channels form or are widened due to channels entering from the adjacent steep badlands.

The suspended-sediment concentrations at the Ah-shi-sle-pah gaging station are predictable for any given runoff because the basin is relatively uniform. This uniformity lends itself to the use of a suspended-sediment discharge/water discharge rating curve for computing the suspended-sediment load. There is some discontinuity between the winter and summer storm runoff relationships because the summer sediment loads are affected by raindrop energy which result in higher runoff. Data for runoff from precipitation that falls as snow plots on the winter curve and data for runoff from rain plots on the summer curve (figure S-2). The average annual suspended-sediment load computed for the gaging station on Ah-shi-sle-pah Wash was 63,100 tons during 1977-78 (table S-2). The 63,100 tons are equivalent to 3.5 acre-ft/mi^2/yr or an average of 0.066 inch of soil removed annually from the entire basin.

Suspended-sediment loads have also been computed for Hunter Wash and De-na-zin Wash, which are located near the Kimbeto EMRIA study area (table S-2). Hunter Wash has produced an average annual sediment load of 120,000 tons during 1975-78, which is a yield of 1.2 acre-ft/mi^2/yr. De-na-zin Wash has produced an average annual sediment load of 369,000 tons during 1976-78, which is a yield of 0.92 acre-ft/mi^2/yr.

Kimbeto Wash drains a fan-shaped basin with eolian deposits and badlands on the surface. Most ridges in Kimbeto basin are topped with eolian deposits, most of which are erosionally inactive and vegetated. The badland areas are located on the south-facing slope. The southern exposure of these badland areas of high sediment yield may affect the snowmelt runoff. The relative consistency of the suspended-sediment concentrations of high-flow samples collected throughout the Chaco River basin indicates that Kimbeto Wash concentrations are similar. The estimated sediment yield from the 65 mi^2 Kimbeto Wash watershed at the study area is 50,000 tons per year, or an average of 0.4 acre-ft/mi^2/yr.

Betonnie Tsosie Wash drains a long, narrow basin. Most wide sandy ridges on both sides of the basin are topped with eolian deposits, most of which are erosionally inactive and vegetated. Most of the badlands are located at the upstream end of the basin; however, there are some small badland areas along the sides or at the ends of some of the steepest parts of ridges. The estimated sediment yield from the 45 mi^2 Betonnie Tosie Wash watershed at the study area is 30,000 tons per year or an average of 0.3 acre-ft/mi^2/yr.

The sediment yields for Kimbeto Wash and Betonnie Tsosie Wash are estimated on the basis of runoff volumes and suspended-sediment samples collected at Ah-shi-sle-pah Wash, Hunter Wash, and De-na-zin Wash. The suspended-sediment yields per unit area from De-na-zin, Hunter and Ah-shi-sle-pah basins show an increase with increases in the percent of badlands within the watershed.

Ground Water

Overburden. The water-bearing part of the deposit above the strippable coal seam (overburden) in the Kimbeto EMRIA study area is extremely low yielding (less than 1 gallon per minute). The highest estimated transmissivity of the three observation wells in the overburden in the study area is less than 0.1 foot squared per day (ft^2/d). The quality of water in the overburden is generally poor. However, as the distance to an alluvial channel decreases (probable principal recharge source), the quality of water in the overburden improves. Detailed water-quality information on major chemical, major physical, and trace element parameters at the three overubrden wells is tabulated in tables S-5, S-6, S-7, and S-8 in section S.

Coal seam. The entire thickness of the coal seam is saturated in each of the coal-seam observation wells in the study area. The estimated transmissivity of the coal seam ranges from 3 to 11 ft^2/d. The ground-water flow, based on limited information, appears to be toward the northwest, parallel to the Chaco River flow. Most of the recharge to, as well as the discharge from, the coal seam is believed to occur where the ephemeral streams cross the coal-seam outcrop. Water-quality information from four coal-seam observation wells is shown in tables S-5, S-6, S-7, and S-8.

Pictured Cliffs Sandstone. The Pictured Cliffs Sandstone underlies the coal seam. This sandstone has an estimated transmissivity of about 3 ft^2/d in the study area and contains water of poor quality. The quality of water in the Pictured Cliffs Sandstone deteriorates down dip (northeast direction) in the area. A summary of water-quality parameters is listed in tables S-5, S-6, S-7, and S-8.

Channel alluvium. The channel alluvium in Kimbeto and Betonnie Tsosie Washes is saturated to within 10 feet of the surface most of the time. The alluvial deposits in these washes range from about 300 to 500 feet wide and from about 50 to 70 feet deep, based on drill holes

near the study area, and contain an estimated 500 to 900 acre-ft of water per mile. The unsaturated part of the alluvium absorbs large quantities of water during stormflows and periods of snowmelt runoff. Well yields of from 10 gallons per minute (gal/min) to 50 gal/min probably could be obtained from these alluvial deposits. The alluvium has the best water quality of all ground-water supplies in the study area. The dissolved-solids concentrations average about 1,500 mg/L. A summary of the averages of the water-quality parameters in the alluvium of the Kimbeto study area is contained in tables S-7 and S-8.

Deep aquifers. There are several deep, high-yielding, water-bearing units or aquifers in the Kimbeto study area. They are: The Cliff House Sandstone at 800 to 1,600 feet, Menefee Formation at 1,600 to 2,600 feet, Morrison Formation at 5,100 to 5,500 feet, and Entrada Sandstone at 6,000 to 6,500 feet below land surface. The aquifers could be expected to yield 100 gal/min, 50 gal/min, 500 gal/min, and 400 gal/min, respectively from a single 8-inch-diameter well. The estimated specific-conductance values of water from these aquifers at the study area are as follow: Cliff House from 1,500 to 4,000; Menefee from 1,500 to 4,000; Morrison from 3,000 to 5,000; and Entrada from 10,000 to 20,000 micromhos per centimeter (umho/cm) (Lyford, written communication, 1979). The dissolved-solids concentrations of the water in mg/L is roughly 70 percent of the specific-conductance value. Wells would have to be drilled into the deep aquifers to determine actual water quality and yield at the study area. A summary of the average values of water-quality parameters in the Morrison Formation in the vicinity of the study area is contained in tables S-7 and S-8. Detailed water-quality information for other deep aquifers near the study area was either not available or from wells too distant to be confidently related to the study area.

Water Supply

Suitable Supplies for Reclamation. Revegetation of mined areas to meet standards set forth by the Surface Mining Control and Reclamation Act of 1977, Public Law 95-87, will require irrigation to supplement the low precipitation in the Kimbeto Study Area. The surface runoff has the best water quality of any water in the study area, but the supply is limited and variable from year to year. An estimated 50 to 80 percent of the runoff from the three major streams in the study area occurs during the growing season, May through September. The runoff volumes of the three major streams were presented previously in this section under the heading Surface Water--Quantity. A major problem with surface runoff is the high suspended-sediment which could be settled out in holding ponds or reservoirs prior to using the water. On the average, there would be about 5 acre-ft of sediment deposited for each 100 acre-ft of runoff stored, assuming an average concentration of 75,000 mg/L.

The water in the alluvial deposits of Kimbeto and Betonnie Tsosie Washes in the study area would be a suitable short-term irrigation

supply for reclamation with respect to quality, but the supply is limited. The water from the alluvium has an average sodium-adsorption-ratio (SAR) of 11 and specific-conductance values of 2,000 umho/cm (table S-3), which would be suitable for irrigation of most salt-tolerant crops. The native plant species that are considered for revegetation exhibit salt tolerance for water with a specific-conductance value as high as 18,000 umho/cm. The irrigation classification of the alluvium water is a medium sodium (alkali) hazard with a high salinity hazard (USDA - Agricultural Handbook 60, 1954). Conditioning the soil with gypsum and selecting plants with good salt tolerance would help overcome the sodium and salinity hazards in revegetation of the mined area. The effect of increased salinity is to retard water availability to the plants by increasing the affinity of moisture to the soil, whereas high SAR values decrease water infiltration into the soil by dispersion and swelling of the soil.

Alternative or supplemental irrigation supplies for revegetation could be drawn from any of several deep aquifers (identified in this report's Ground Water-Deep Aquifer section) at the study area. Water quality would be the limiting factor. Only limited information in available on the deep aquifers, and wells would have to be drilled to test actual water quality and yields at the study area. Water from deep aquifers could be blended with surface runoff if the sodium or saline hazard needs to be reduced in order to become suitable irrigation water. The U.S. Salinity Laboratory Handbook considers any water supply with an SAR value less than 18 to be useable for irrigation. Other water-quality characteristics of the water supply in the Kimbeto area need to be considered before using the waters for a reclamation supply; these are the high bicarbonate values and the trace element values. Bicarbonate with calcium will tend to impair the permeability of the soil by chemical precipitation of calcium carbonate, but the water supplies in the Kimbeto area contain relatively low calcium concentrations. High bicarbonate, however, also will precipitate with iron, making the iron, an essential plant nutrient, unavailable to the plants. The concentrations of dissolved trace elements found in the Kimbeto area surface-water supplies are not regarded as being detrimental to plants. These elements include boron, to which most vegetable crops are sensitive, and selenium, which may be concentrated by plants to levels that may be toxic to foraging livestock. The high total trace-element concentrations present because of the high suspended-sediment concentrations are not likely to be a problem because of the high alkalinity of the water and the soil. The trace elements would be desorbed from the suspended sediment only under very acid conditions. Any acid produced from exposure of sulfide minerals would be neutralized by the high natural alkalinity of the soil.

Availability for Mining Operation. Water-quality requirements for the mining operation are not stringent because the primary uses probably will be for coal washing or dust control. An adequate and reliable water supply from any of several deep aquifers (see Ground Water-Deep Aquifer section) could be developed at the study area.

SECTION K

PRESENT LAND USE, POST-MINING LAND USE, AND LEGAL REQUIREMENTS PERTAINING TO MINED-LAND RECLAMATION

SECTION K

PRESENT LAND USE, POST-MINING LAND USE, AND LEGAL REQUIREMENTS PERTAINING TO MINED-LAND RECLAMATION

Present Land Use

The Kimbeto study area is presently used by many entities for various purposes. The most extensive use is that of livestock grazing by local operators (both Indian and non-Indian). Several kinds of livestock use the study area, including sheep, goats, cattle, and horses.

Some of the livestock operators themselves use the land to live on, either as permanent housing or as temporary quarters while their livestock are in certain areas.

Another major use of the study area is for access to the Chaco Canyon National Monument, which is just south of the study area. State Highway 56, which bisects the study area, is a well-used dirt road used by many visitors to the monument. Several electrical power distribution lines cross the study area, providing electricity to the National Park Service and local residents. Also, a telephone line crosses the study area, paralleling State Highway 56.

The BLM and the Bureau of Indian Affairs have used the land to construct various erosion control devices, such as dams and diversion ditches, which are used primarily for watershed protection.

There is some use of the study area by wildlife. Due to poor water distribution, the number of species adaptable to the study area is small. Birds, reptiles, and some rodents make up the known species of the study area.

Post-Mining Land Use

At this time, the only indicated use of the land after mining will be for livestock production and wildlife habitat. It must be understood that there will be many public meetings on this and other subjects before strip mining commences. Other uses for the area may be indicated at that time. These additional proposed uses will be evaluated in the BLM's multiple-use planning system. This system may determine that the alternate uses are warranted and that the objectives of post-mining use should be altered.

If grazing and wildlife habitat are the only uses identified through the system, the objectives of post-mining land use would read as follows:

1. Establish palatable perennial native vegetation that will produce quantities that equal or exceed the forage production the land would produce before mining.

2. Establish vegetation species that promote and/or enhance various wildlife species.

The Bureau of Land Management's District Management Framework Plan, which describes the above post-mining land uses for the study area, may be inspected at the Bureau of Land Management District Office, 3550 Pan American Freeway, NE., Albuquerque, New Mexico 87107, and at the Farmington Resource Area Headquarters, 900 La Plata Highway, Farmington, New Mexico 87401.

Legal Requirements Pertaining to Mined-Land Reclamation*

If the Kimbeto study area is leased for coal mining, because it is Federal land, the operator of the mine must comply with Federal regulations. Furthermore, because the operator will not be an instrumentality or agent of the Federal Government, he must comply with State regulations. There are no local regulations concerning coal surface mining.

Federal regulations

The major Federal coal mining operating regulations were published in the Federal Register, Vol. 41, No. 96, May 17, 1976 (part II, pages 20253-20273). Selected passages of the regulations are presented in section T, some in modified form. Also presented in section T is the proposed regulation Title 30, Chapter VII, part 700, section 700.1. Other pertinent Federal regulations were published in the Federal Register in Vol. 41, No. 90, May 7, 1976 (pages 18845-18848) and in Vol. 41, No. 105, May 28, 1976 (pages 21779-21781).

State regulations

Presented in section T, some in modified form, are selected passages from the regulations of the State of New Mexico, Coal Surface Mining Commission (effective date--February 9, 1973), pursuant to New Mexico Coal Surface Mining Act, Chapter 68, Laws 1972.

---

* See Hydrology and Water Supply Conclusions in Section L for additional discussion of pertinent legal requirements and regulations.

SECTION L

CONCLUSIONS ON STUDY AREA RECLAMATION POTENTIAL

SECTION L

CONCLUSIONS ON STUDY AREA RECLAMATION POTENTIAL

Alternatives

Four alternatives relative to post-mining reclamation were considered and are discussed below: (1) no mining, (2) natural recovery, (3) total revegetation, and (4) restoration of existing levels of vegetation. Alternative (4) was jointly selected by BLM, GS, and BR as being the most reasonable. This alternative is discussed in detail below.

No mining

An alternative to reclaiming the study area following mining is not to mine in the first place. A main purpose of this report, however, is to study the reclamation potential of the study area following mining. The report, therefore, assumes that mining will take place. However, the decision whether to mine has not been made and will not be made until an environmental impact statement studying the economic and environmental impacts of strip mining at the study area is completed. Therefore, the no mining alternative is not discussed further in this report.

Natural recovery

The following alternative assumes that Federal or State regulations would allow the alternative, which is unlikely.

Under this alternative, materials suitable for planting media would not be separated from unsuitable materials. Spoil piles would simply be shoved back into the pits after the coal has been removed, minimally graded, and left for natural revegetation. Natural revegetation would be a slow process, at best, in this arid region, although the time required for it has not been determined. Indeed, these spoil piles, consisting mostly of materials unsuitable for revegetation, might never become revegetated. Through wind and water erosion, unvegetated spoil piles could contaminate adjacent unmined land areas and downstream water supplies. Local wildlife and domestic stock would be deprived of vegetation for cover and grazing until vegetation is reestablished. Whatever esthetic value the study area now has would be lost because the existing land forms would be destroyed and the new ones would be haphazard and subject to wind and water erosion until revegetation occurs. For these reasons, this alternative is deemed unrealistic and is not considered further in this report.

Total revegetation

At present, the study area is only partially vegetated. Revegetation of the entire surface-mined area would be very difficult because this would require that the entire study area have a covering layer of planting media of adequate

thickness. Based on the land suitability classification performed for the study area (see section F), there are insufficient planting media within the study area. Therefore, additional planting media may have to be borrowed from outside the study area. This would require another land classification survey to properly identify suitable soils. If planting media were found and transported to the study area, a revegetation program would have to be conducted at the borrow site.

Therefore, if the study area is entirely revegetated, the revegetation program would be similar to that for restoration of existing levels of vegetation except that it would be more extensive and costly, and the two major limiting factors in the area of the study area--available planting media and irrigation water--would assume greater importance.

In light of the difficulty of restoring existing levels of vegetation at the study area, total revegetation of the study area appears unrealistic. In addition, restoration of existing levels of vegetation is consistent with the guidelines for this EMRIA study:

(a) Work Order No. 18, agreement between BLM and Water and Power concerning EMRIA study areas, dated December 1976, which states that the specific study plan for the study area will contain data interpretations and recommendations for reclamation methods to return the land to premining condition and use and/or to conditions suitable for alternative uses identified by BLM; and

(b) Work plan for Kimbeto study area, transmitted by Water and Power to BLM June 11, 1977, which states that an evaluation of the post-mining reclaimability of the study area will be made, directed [in part] at reclamation potential based on livestock grazing, wildlife habitat, and for watershed protection as the post-mining land use.

For these reasons, the alternative of total revegetation of the study area is not considered further in this report.

Restoration of existing levels of vegetation

Under this alternative, the entire study area would be carefully graded and existing levels (at least) of vegetation would be restored; grading and location of vegetation would not necessarily be the same as at present. Areas not revegetated would be reclaimed so as to minimize erosion and then allowed to revegetate naturally. The plans presented in detail below (Land and Overburden Conclusions (Reclamation by Restoring Existing Levels of Vegetation)) for implementing this alternative could be carried out with or without irrigation, as indicated. Since revegetation of arid areas such as the Kimbeto study area is difficult, this alternative appears to be the most logical of those presented and is recommended accordingly. Recommendations in other "conclusions" subsections of section L should also be followed for successful reclamation.

Land and Overburden Conclusions* (Reclamation by Restoring Existing Levels of Vegetation)

Actions during the premining and mining periods

Selection of planting media. Existing suitable surface soils (classes 1 and 2) appear to be the only source of planting media.

These soils have some organic matter content and adequate physical condition, are easier to physically handle, and probably already contain some native seeds which would aid in vegetation and establishment.

The soils usually occupy mesas, ridges, and elevated benches of the study area. Just before starting the mining operation, a detailed site inventory should be completed, however, to pinpoint the location of and to more carefully evaluate the planting media of the study area.

Laboratory analysis of bedrock overburden at the study site indicates that it is unsuitable (as defined in table F-1) as planting media in its present condition (see table Q-10 for results of laboratory analysis). However, reclamation at the nearby Navajo Coal Mine indicates that revegetation of overburden material that includes bedrock may be possible. Therefore, further studies should be made of bedrock overburden at the Kimbeto study area to determine if it is suitable as planting media.

A comprehensive test-plot program should be conducted at the study area before mining begins. The program should include use of bedrock overburden as a planting media; simulation of growing conditions and techniques appropriate to the study area; and use of commercial developments for erosion control and revegetation.

Handling and placement of soil and bedrock material

Stockpiling of soil or bedrock to be used on surface--During mining, existing suitable surface soils should be stockpiled so as to be readily identifiable in order that they can be properly placed on the surface during final forming of reconstructed landforms. Both residual clay material and wind-blown sandy material occur at the study area. It is essential that both of these soil materials be removed and stockpiled separately. During stockpiling, suitable planting media must be separated from unsuitable materials, and contamination kept to a minimum. All stockpiles must be protected from erosion. Long axes of the stockpiles should approximate the prevailing wind direction to minimize wind erosion. Undue compaction of planting media should be avoided during handling.

* Because different authors prepared different parts of this report, conclusions in one part of the report may not completely agree with those in another part.

Probable resulting soil profile--Since suitable planting media is limited, the reconstructed soil profile will probably be somewhat shallow. Some of the vegetation at the study area is found on areas with less than 18 inches of soil material. There are also partially barren areas where sparse vegetation grows on very shallow eolian deposits, sometimes less than 12 inches thick. These examples of existing vegetation indicate that a large amount of planting media is not needed for some species of plant growth.

Almost all the planting media will have some coarse textures with variable hydraulic conductivity, but some of the planting media will have medium to fine textures with limited permeability. The planting media should be spread in strata so that a foot or more of the finer textured soils are near the bottom (to impede infiltration of water). On top of that layer should be placed 12 to 16 inches of sandy material composed of particles of various sizes; the minimum thickness of this layer of sandy material should be about 8 inches.

Some sodic and saline soils will be included in the planting media but will be within the suitable category. Indeed, the sodic soils may be an asset in establishing and maintaining vegetation because sodic conditions impede moisture movement in soils, reducing the rapid permeability of the coarse-textured soils. Some materials classed as 6 because of high sodicity could be used as a barrier and planting media distributed over this barrier. Moisture would accumulate in the upper layer and be more readily available to vegetation.

Placement and isolation of toxic materials. A factor to be considered during handling of overburden will be the proper disposition of toxic materials. Laboratory analysis and greenhouse tests of the overburden material sampled in 1976 reveal that much of the soil and bedrock overburden at the Kimbeto study area, while not toxic, is sodic or saline.

All materials identified as toxic before and during mining should be stockpiled; isolated; protected to prevent contamination of water supplies and planting media; and placed after mining below root zones so as to preclude contamination of water supplies.

Grading. One objective of replacing overburden and reshaping topography should be (a) the creation of final topography which will blend with the form of the adjoining undisturbed landscape and (b) the reestablishment of a positive surface drainage pattern. Reshaping to blend may not always be desirable, however. It should be possible to reduce the steeper slopes, which are usually of relatively short reach. This reduction of slopes would lessen erosion hazard, increase the potential for successful revegetation, and reduce operational problems.

Well-planned grading will promote full use of precipitation for establishing and maintaining vegetation. This could be accomplished by constructing a series of shallow depressions and diversion structures and by contour furrowing. If the landscape is arranged for natural rainfall collection, plants may take

advantage of the rainfall to increase their chances of survival after irrigation (if used) is discontinued.

Slopes should not be steeper than 3 to 1 and, wherever possible, should be 4 to 1 or 5 to 1. Final grading should assure that no flat areas are created which will pond water unless temporary ponding is a part of the precipitation collection plan or erosion control program. Thus, if sand is not available for planting media in some areas, it would be advisable to surface these areas with finer-textured materials graded so that the surface is almost flat. Runoff could be reduced by treating the surface with an Arcadia furrower so that all the water falling on a site is retained until it infiltrates the soil. Water would be stored at shallower depths than in sandy soils, and a higher proportion of this water would be evaporated instead of transpired. Xerophytic shrubs and, possibly, certain short grasses could survive under these conditions.

Drainageways should be provided with grades flat enough to prevent gullying and excessive channel erosion. Flow retarding structures may be desirable. Resulting stream channels should have slopes equal to or less than those occurring before mining. Contour furrowing or some other practice should be done to temporarily minimize runoff until a grass cover has been established.

Grading plans should provide for permanently conducting drainage from the badland escarpment across the reclaimed area or for permanently diverting the drainage around the area.

Topographic plans for the finished areas should maximize north- and east-facing slopes. South- and west-facing slopes are drier and hotter in this area, thus making them more difficult to revegetate.

Sculpturing (excessive manipulation or grading) of the plant media should be avoided. A test plot program should provide information on effective grading techniques. Placement of planting media should be avoided during windy periods.

Actions during the post-mining period

Evaluation of surface material for revegetation. This subject was introduced above in "Actions during the pre-mining and mining periods." The surface material used for planting media would be predominantly coarse textured. Some mixing of classes may be desired in order to acquire a more suitable texture, although doing so may lower the overall quality. Also, combining of classes into layers to promote utilization of irrigation or rainwater will be desirable. All planting media classed as suitable will support sufficient vegetation for reclamation with proper managment.

Although most bedrock materials do not appear suitable as planting media, this should be confirmed by a test-plot program and by reclamation at the nearby Navajo coal mine.

Selection of plant species

Native species (first priority)--Vegetation now grows on parts of the study area. This indicates that revegetation may be accomplished with arid land plant species. Other species may require more water than prevailing climate patterns provide. If possible, seeds should be obtained from local growers in order to be more climatically adapted and capable of survival at the study area.

The study area will probably continue to be used for grazing of domestic animals and wildlife following mining. For this reason, a variety of both herbaceous and woody species should be seeded following shaping of the land surface and placement of planting media. The native species most suitable for revegetation include the following:

Grasses

Common name	Scientific name
Blue grama	Bouteloua gracilis
Hairy grama	Bouteloua hirsuta
Alkali sacaton	Sporobolus airoides
Galleta	Hilaria jamesii
Indian ricegrass	Oryzopsis hymenoides
Ring muhly	Muhlenbergia torreyi
Sand dropseed	Sporobolus cryptandrus

Shrubs

Big sagebrush	Artemisia tridentata
Black sagebrush	Artemisia nova
Fourwing saltbush	Atriplex canescens
Mormontea	Ephedra sp.
Shadscale	Atriplex confertifolia

Appropriate seed mixes and seeding rates for the study area should be determined by BLM. Seed availability may be questionable for some of the above species. A test-plot program should provide provide information about successful species, mixes, and seeding rates.

Adapted introduced species (second priority)--Because of the climatic conditions of the areas, no introduced plant species are recommended for seeding. However, research by other agencies and mining companies and a test-plot program may reveal additional suitable species for the study area.

Nutrient deficiencies-additives. Fertility analysis of the planting media was not performed. Use of fertilizer (N_1P_1K) and additives (H_2SO_4, Gyp., etc.) should enhance plant growth, but tests are required to confirm this and to

establish the fertility of other overburden materials. A test-plot program should provide information.

Irrigation. Because of the arid climate, post-mining establishment of vegetation at the study area without irrigation will be difficult. Without irrigation, timing of seeding will be crucial because seeding will have to occur when moisture from rain or snow is present; but precipitation at the study area is erratic. Moisture may not be present when most needed to support newly seeded areas. With no moisture or vegetation to hold the soil, wind erosion could carry off the soil and the seeds or leave the seeds exposed. The seeds could be planted again; but the soil, in short supply at the study area, would be lost. The erratic precipitation patterns might produce too much moisture--a cloudburst (not uncommon at the study area) that could sluice off the valuable unprotected soil. If there is moisture at the right time and in the right amount, the seeds would germinate. Then, if the next rain is too hard, the seedlings will be carried off with the eroded soil; or if the rain is inadequate, the seedlings will wither and die. In either event, the topsoil would again be susceptible to the scouring wind.

If irrigation is practiced as recommended by some authorities, seeding would not be so subject to the study area's erratic rainfall patterns. Germination and young plant growth would be quickly established and securely supported. The chance of wind or water erosion would be considerably less. A denser plant population would become established. If some plants died when irrigation was removed, the denser population should increase the chances that some plants will survive. The shock of removal of irrigation would be lessened by gradual withdrawal of irrigation.

Some authorities hold that the shock of removing regular fertilization and irrigation will seriously weaken or kill new plants and that revegetation should accordingly be accomplished without irrigation. At the nearby Navajo coal mine irrigation is being used to grow vegetation on spoil material. This irrigation has not been practiced long enough, however, to prove its worth. The benefits of irrigation in revegetation of areas such as the study area may, therefore, be in dispute.

Although additional research is needed to resolve this controversy, the authors of this report believe that temporary irrigation has the best chance of producing quick successful revegetation at the Kimbeto study area. A test-plot program should confirm the effectiveness of irrigation.

Another question concerns economics. Assuming water supplies for irrigation are technically feasible, it should be determined whether it is economically feasible to irrigate at the study area. One approach to such a determination would be to compare the cost of irrigation for 2 years to the cost of 10 successive years of seeding (including the cost of erosion control). The latter alternative might be required in order to establish vegetation without irrigation because of the erratic rainfall patterns and other harsh climatic and soil conditions at the study area.

Use of irrigation does not affect the plans for revegetating the study area presented in this report. The only difference would be that under irrigation revegetation should occur sooner and more successfully. If irrigation is chosen, plants would be irrigated for their entire first year, receiving 15 inches of water. The following year they would receive one spot irrigation of about 2 inches during the growing season to wean them from irrigation.

Alternative irrigation systems would be "solid set" (best); "hand move" (next best); and "side roll" or "center pivot" (next best).

Most planting media are coarse textured with a low available water holding capacity of .75 to 1.75 inches of water per foot of media. However, placing finer textured soils or weathered bedrock (both having limited permeability) under the coarse-textured planting media will increase the amount of water the latter can hold to about 2.2 inches per foot of media. With a recommended average depth for the coarse planting media of about 14 inches, the average amount of available water should be about 2.5 inches. Light and frequent irrigations, keeping the surface few inches of planting media moist, should keep all of it moist and enable germination, young-plant growth, and maintenance of vegetation.

Mechanical manipulation of in-place planting media will be necessary only if nonsandy planting media are used.

In areas where drainage ways collect water in sufficient quantities to cause erosion, water spreaders should be considered. Water spreaders are systems of dikes designed to divert floodwater from a gully onto adjacent rangeland. Because of the normal low rainfall in this area, it can be expected that water spreaders would come into play only during rains of high intensity and during periods of rapid snowmelt.

A test-plot program should provide information on the above techniques.

Seeding methods. Test plots and fertility tests should provide information about seeding methods. More than one seeding may be required, especially if irrigation is not practiced. The time of year when seeding should take place will depend on the particular seed mix being planted. Reclamation should be scheduled so that seeding takes place soon after final grading in order to avoid surface erosion. The species to be planted at the study area will have optimum seeding depths. Selection of the manner of seeding (see below) should be based on these depths. Seed may be planted by an approved disk or shoe-type grass drill; an approved hydroseeder; or mechanical or hand broadcasting. Drilling is the preferred method.

Drill seeding--Sowing the seed mixture with either an approved disk or shoe-type grass drill is acceptable. If this method is used, the drill shall be regulated to uniformly distribute the seed at the rate specified for the study area. Where possible, drilling shall be done on the contour or parallel with the slopes being seeded. The drill shall be regulated so that

the seed is properly placed in the soil and covered with soil to the specified depth. If fertilizer is to be applied during seeding, the drill could be equipped with an approved fertilizer attachment for distributing fertilizer at a specified rate simultaneously with the drilling of the seed.

Hydroseeding--Seeding with an approved hydroseeder will be acceptable provided wind velocities permit uniform distribution of seed and nitrogen fertilizer slurry on the areas to be seeded. In hydroseeding operations, the mixture of seed and the fertilizer specified shall be properly mixed with water to form a slurry. The slurry mixture shall be prepared immediately prior to application and shall be promptly applied on the areas to be seeded and fertilized. Slurry mixtures prepared more than 1 hour prior to application are not acceptable. The hydroseeder shall be designed to assure that seed and fertilizer are uniformly applied at the recommended rates per acre. The hydroseeder shall be equipped with a paddle-type agitator and recirculation pump that will continually stir and mix the slurry to prevent settling of solids in corners and at the bottom of the tank and to maintain a uniform mixture of seed, fertilizer, and water at all times during the entire seeding operation. Immediately after the slurry mixture is applied to the soil surface, the seed shall be properly covered with soil to the specified depth.

Mechanical broadcasting--A mechanical broadcaster of either the centrifugal type or pull type similar to fertilizer spreaders is acceptable. Any equipment of this type used for broadcast seeding shall be designed and regulated to assure that the proper seeding rate per acre is uniformly applied on areas to be seeded. When this method is used, seed and fertilizer may not be applied in the same mixture simultaneously; each shall be broadcast separately.

Hand broadcasting--Hand broadcasting may be performed on small inaccessible areas. Seed application may be performed by using an approved hand broadcaster or by broadcasting the seed by hand from a sack or other suitable container. Whichever means is used, the seed shall be uniformly applied at the specified rate. When using this method, the seed and fertilizer shall be broadcast separately. Hand broadcasting is the preferred method for areas where drill seeding is impractical.

Additional planting procedures--Monocultures should be avoided in grass stand selection. A good mix of adapted species which are drought resistant and have good sod-forming characteristics should be selected. When a range mixture is used, determination of the recommended seeding rates should include the results of the test plots. Some seeds may be planted by mixing them with mulch (see below). The BLM's Farmington office can provide references to assist in choosing seeding methods.

Fertilizer application. Fertility tests and a test-plot program should provide applicable information. If required, fertilization during seeding may be done as indicated above. Later in the growing season or in subsequent growing seasons, additional light applications of fertilizer may be desirable.

Timing and rate of fertilizer application should be determined by the local manager, since they will have to be based on local observation and experience.

Surface soil protection. Selected mulch material shall be applied at the recommended rate immediately after planting and fertilization, and shall be anchored as appropriate. Following the mulching operation, wind barriers (snow fences) may be installed.

After seeding is completed, mulching is used to stabilize critical areas and enable plants to become established quickly in the surface material. Mulching nearly always shortens the time required to establish a suitable plant cover by reducing evaporation, moderating soil temperatures to promote germination and seedling growth, preventing crust, and controlling wind and water erosion. Any substance spread, formed, or left on the surface may act as a mulch. There is a large variety of available mulching materials, including: straw, native hay, hay and other crop residues, sawdust, woodchips, wood fiber, bark, manure, brush, jute or burlap, uniform-sized coarse sand, gravel, mulch stones, peat, paper, leaves, plastic film bits, bottom ash, and various organic and inorganic liquids. In addition, commercial products and systems for protection of surface soils are available and should be considered.

Gravel or crushed rock can also be selected from overburden material and used successfully as a surface mulching material. These types of mulches have advantages over most other mulches because they are permanent if the individual pieces are no smaller than one-eighth inch in diameter. If the gravel or crushed stone pieces are no smaller than this in size, the mulch cover will withstand a surface wind velocity of 85 mi/h. To control wind erosion the pieces must almost cover the soil surface (not less than 95 percent). The finer the gravel or crushed rock the less material is required to cover the ground surface.

Before a mulch is selected, systematic evaluation of the advantages and disadvantages of each type should be made considering factors such as transportation problems, application problems, resistance to erosive forces, insulating and evaporation-retarding capacity, etc.

Protection of the surface soils from sustained high winds is essential. One method that has been successfully used to reduce surface erosion, as well as prevent injury to tender growing seedlings being established on a site, is to use wooden slat snow-fencing material 5 to 6 feet in height. These fences should be installed perpendicular to the prevailing winds during the winter and spring seasons and should be located about 100 yards apart or closer if needed. The snow fence can be constructed with steel fence posts that can be driven into the soil or with wood posts that are hand set. Because of their costs and possible interference with irrigation activities, it may be desirable to limit placement of snow fences to only those areas which develop wind erosion problems after the 2-year irrigation period.

A test-plot program should provide information on mulching and fencing techniques. The BLM's Farmington office can provide references to assist in choosing mulching techniques.

Management. Grazing management is a necessity during revegetation. The new seedlings must be protected from grazing for at least three growing seasons; on the harsher sites, four or more growing seasons may be necessary. The young seedlings should not be grazed until they are firmly rooted. Adequate fencing will be required to prevent grazing by livestock during the establishment period.

Undesirable weeds may present harmful competition to seeded perennial species during the first two or three seasons after planting. It may be desirable to control these weeds through the use of selected herbicides during at least the first year of growth.

Overburden Geochemistry Conclusions

Summary of study area characteristics in relation to reclamation potential

The various Kimbeto overburden rock types are congruous in their bulk chemical composition with the same rock types at other sites in the Western United States where Cretaceous age rocks overlie coal. The single major exception is higher sodium content in Kimbeto overburden. The rocks are also generally similar in bulk chemical composition to the native soils of the San Juan Basin. On the basis of their bulk chemistry, the overburden rocks could be used as acceptable soil replacement material and should not be expected to have long-term unfavorable effects on element concentrations in ground water. However, for determining the immediate suitability of the rock as a replacement for the soils of the study area, other factors must also be considered. These other factors were the basis for the suitability determinations previously discussed in this section under the heading Selection of Planting Media and in section F.

Reclamation potential of the study area based on anticipated post-mining use as designated by BLM (livestock production and wildlife habitat)

There is no reason associated with bulk chemistry of the overburden rocks that the area should not be restored to a condition which would allow its designated post-mining use.

Major reclamation problems and measures necessary to establish conditions suitable for anticipated post-mining use

It may be necesary to stockpile rocks in a segregated manner, by distinct lithic types, in order to allow replacement of rocks in the refill column in positions best suited to their particular chemical character. For example, it would likely be desirable to place sandstone, with its potential loamy texture and comparatively low trace- and minor-element concentrations, near the top where it

would have most contact with plant roots and would permit absorption of intense rain showers; it would likely be desirable to place claystone, with its higher elemental concentrations, either deep in the refill column where the reducing electrochemical potential would retard weathering and release of elements to ground water, or else in the middle of the refill column where it would be physically distant from either roots or ground water and could form an impermeable barrier to downward movement of elements from the surface and to downward loss of soil moisture.

Vegetation Conclusions

Important study area characteristics in relation to reclamation potential

In general, the study area has low vegetation productivity owing to low annual precipitation, sporadic occurrence of precipitation, high runoff from some areas, and replacement or reduction in vigor of palatable and productive species. Major forage species include alkali sacaton, galleta, ring muhly, and blue grama. Major shrub species that provide wildlife habitat in addition to some browse include big sagebrush, rubber rabbitbrush, and greasewood.

Reclamation potential of the study area based on anticipated post-mining land use (livestock production and wildlife habitat)

Reclamation potential is low because of the climatic and soil conditions which make revegetation difficult.

Major reclamation problem

The major reclamation problem will be to provide soil-moisture conditions adequate for the reestablishment of vegetation.

Soil-Moisture Relationships Conclusions

Important study area characteristics in relation to reclamation potential

Vegetation cover is sparse in the badlands and on the flood plain areas among the low dunes on the alluvial plains. Because the soils are fine-textured and poorly permeable, a relatively large percentage of the precipitation runs off. Also any moisture that does infiltrate the soil is stored near the surface where much of it is lost by evaporation.

Sites on the study area with the most vegetation cover are those where sandy surface soils are underlain by finer-textured, less permeable layers at depths of 1 to 2 feet. Drainage is impeded at these sites, therefore, soil moisture is more readily available to vegetation, especially grasses. Also, loss of moisture by evaporation is retarded by the sandy materials at the soil surface.

The climate of the area is hot and dry during much of the growing season, which will make it difficult to establish vegetation during reclamation. This problem

is compounded by the low moisture-holding capabilities of the sandy soil materials prevalent in the area. The sandy material is also quite vulnerable to movement by wind, which presents another hazard to vegetation seedlings.

Reclamation potential of the study area based on anticipated post-mining uses

The reclamation potential is low because of the adverse climatic, soil, and soil-moisture conditions that were discussed in the preceding three paragraphs.

Major reclamation problem

The major problem will be the difficulty in reestablishing vegetation.

Measures necessary to establish conditions suitable for post-mining uses of livestock production and wildlife habitat

Opportunity exists during rehabilitation for increasing forage production and improving the wildlife habitat with respect to pre-mining conditions. The means for doing this are discussed in the remaining paragraphs.

Sandy soil materials from dunes and mesas and fine-textured alluvium from the alluvial plains on both sides of Ah-shi-sle-pah Wash should be stockpiled separately. After the spoils are shaped, a layer of the fine-textured material about 1 foot thick should be put down and compacted. A layer of the sandy material about 2 feet thick should be placed on top for growth media.

Some type of mulch will be necessary to stabilize the sandy material to prevent wind erosion and reduce evaporation during establishment of vegetation. Sprinkler irrigation during the first one or two growing seasons after seeding would insure that some cover is established from the outset.

Sediment Yield Conclusions

Important study area characteristics that influence the reclamation potential

The precipitation is sporadic and most events that result in streamflow are caused by intense rainstorms.

The badlands areas are steep, nearly impermeable, and vegetation on them is sparse. All of these factors result in high rates of runoff, erosion, and sediment yield. Besides the onsite loss of potential soil material, the flows contribute to downstream flooding and sedimentation on both local and river basin scales. Locally, the flows arising in the badlands cross alluvial plains that are underlain by surface-mineable coal.

Reclamation potential of the study area based on the planned post-mining land uses

The reclamation potential is low regardless of the planned post-mining land uses. At least two expensive erosion-control practices would need to be implemented to meet water-quality regulations during mining and to prevent greater rates of erosion and sediment yields after mining and reclamation as compared to before.

Flows arising in the badlands, including the flows in Ah-shi-sle-pah Wash, need to be diverted around the mine area to prevent flooding of the mine and to prevent excessive channel erosion of the area after reclamation. The diversion channels would be in erodible materials, so they would need to be stabilized by means of durable linings. The diversion channels will lower the base levels of most tributaries, so hydraulic structures will be needed at the confluences of the tributaries and the diversion channels to prevent headward downcutting erosion of the tributary channels.

Another erosion-control practice that would be feasible, particularly since the land is being disturbed anyway, would be to take sandy materials from the mesas and from the riparian dunes along the main washes, such as Kimbeto Wash, for use as growth media on areas where suitable materials did not exist before mining. Such a practice would minimize runoff from and erosion of areas underlain by poorly permeable materials, and would greatly increase forage production and cover where vegetation was sparse prior to mining.

Major reclamation problem

The major problem will be to prevent erosion of diversion channels and downcutting of drainageways that are tributaries to the diversion channels. Runoff and sediment yield from fine-textured spoil material would be a problem that is nearly as important.

Measures necessary to establish condition for post-mining land uses--livestock production and wildlife habitat

Two of the measures have been discussed above under Reclamation Potential of the Study Area Based on Planned Post-Mining Land Uses. Another measure needed would be to design and construct broad, laterally flat drainageways in the reclaimed landscape to minimize erosion from any flows that may originate within the reclaimed area.

Hydrology and Water Supply Conclusions

Effects of surface mining and subsequent reclamation on hydrology

Probable impacts on hydrologic budget. Surface mining and reclamation would have some impact on current water uses and the hydrologic budget in the

Kimbeto study area. The area is being utilized for domestic livestock grazing and for support of wildlife. Surface-water uses consist of livestock and wildlife watering from temporary supplies trapped in small natural depressions or potholes located in streambeds. There are several small reservoirs for storage of surface runoff in or near the study area that are also used for livestock and wildlife watering. Ground water is used for domestic purposes and supplementary livestock water supply. The ground water supply is obtained from wells in the alluvium near Kimbeto and Betonnie Tsosie Washes.

Impoundment of surface runoff at the study area for reclamation or mining would alter the natural peak discharges, runoff volumes, and recharge to the alluvium of streams downstream from the study area. There also would be high evaporation losses in any reservoirs constructed because of mining. The water quality regulations of the Surface Mining Control and Reclamation Act of 1977 Public Law 95-87, would prohibit the discharge of poor quality surface water from disturbed areas. These water quality regulations would apply except when the runoff results from a precipitation event larger than a 24-hour event with a 10-year recurrence interval. Decrease of ground water recharge would lower the water table in the alluvium downstream from the impoundment. Two wells finished in the alluvial fill in the study area and one shallow well downstream from the study area would probably show this effect. The effects of altering the runoff and ground water recharge would be localized primarily from the reaches in the study area to the confluences with the Chaco River. The drainage basins of the streams in the study area collectively represent approximately 10 percent of the drainage area to the Chaco River upstream to and including Escavado Wash. Because surface runoff eventually would be returned to the restored and natural channels after reclamation, the effect of the decreased ground water recharge would be temporary and last only during mining or immediately thereafter. The surface runoff as a supply, however, is limited and unpredictable because of sporadic annual precipitation of about 8 inches.

Surface mining for coal would break up the stratified overburden and water-bearing coal seam, replacing them with crumbled shale and sandstone rubble with a porosity greater than the original material and containing a high percentage of material exposed to weathering. The returned overburden, now more permeable, would contain a higher volume of water with the quality similar to water in undisturbed overburden. Loss of flow to the mined-out areas could be minimized by lining reconstructed channels through the mined-out areas with an impermeable layer of clay or construction of dikes to prevent floodflows from spreading over the replaced overburden.

Ground water withdrawals from the Morrison Formation for mining and reclamation would alter the normal northwest flow patterns. A component of flow would be toward the center of a cone of depression at local withdrawal points. Modeled potentiometric-surface contours are shown in figure S-3, in section S. Model-simulated drawdowns that would result in the Morrison Formation at the end of 10, 20, and 40 years at a withdrawal rate of 400 gallons per minute (gal/min) at the study area are shown in figures S-4, S-5, and S-6 (Lyford and Frenzel,

written communication, 1978). The maximum drawdown at any point of withdrawal from the Morrison Formation could be 5,000 feet. Withdrawal from other deep aquifers in the study area would produce similar results. Any ground water that is pumped to the surface for use will be of higher silinity than any local surface-water supply. Ground water from a deep aquifer that is discharged into channels would have the potential to increase the silinity in ground water in the channel alluvium. The Surface Mining Control and Reclamation Act of 1977 prohibits the release of poorer quality waters into natural channels, compliance with this regulation would help protect the existing quality of the water in the channels.

Reclaiming the mined-out areas would have an effect on the surface runoff characteristics from the study area. Assuming the reclaimed areas are topped with sandy material, peak flow discharges, and runoff volumes from the study area will be decreased. Reclamation would eliminate badlands in some areas mined. The badlands are exposed on about 40 percent of the study area and probably account for most of the surface runoff. A precipitation-runoff modeling project funded by BLM is underway; its purpose is to develop a prediction of runoff characteristics during surface mining and after reclamation.

Potential changes in sediment yield. Surface mining for coal in the Kimbeto study area would disarrange the stratified overburden into a series of spoil-pile rows made up of crumbled shale and sandstone rubble. The spoil-pile rows would initially have side slopes equal to the angle of repose of the disturbed overburden. Some of the exposed shale would be broken into fine particles which would infiltrate and seal the spoil-pile surface.

The Surface Mining Control and Reclamation Act of 1977 requires the mining companies to reclaim the spoil piles on a current basis to within one to three rows of the active mine pit and prohibits the release of surface runoff from raw or partially reclaimed spoil piles which do not meet the water quality standards set forth in the act. The act requires that the spoil piles be graded to gentle slopes, topped with planting media, and revegetated. Surface runoffs that are not required to meet water quality standards set forth in the act are runoffs resulting from precipitation with a rainfall frequency greater than that expected from a 24-hour event with a 10-year recurrence interval.

The total suspended-sediment yield from the Kimbeto study area, if mined, may be less after reclamation than under natural conditions. The relative suspended-sediment yields after reclamation would be decreased significantly from mined badlands and would be increased slightly from mined sandy mesas and sand dunes areas. The predictions of relative suspended-sediment yields are based on suspended-sediment samples collected from Ah-shi-sle-pah Wash where about 85 percent of the watershed is badlands and Tsosie Swale which is mainly a sandy mesa. Averages of suspended-sediment data collected at Ah-shi-sle-pah Wash and Tsosie Swale are contained in table S-3. The flow and water quality characteristics of Tsosie Swale could represent hydrologic conditions that probably could be achieved with an effective reclamation plan.

Compliance with water-quality regulations. The quality of surface waters and ground waters originating on, flowing through, or discharging from a mine at the Kimbeto EMRIA study area would fall under the control of water-quality regulations depending on the source, use, and discharge of the water onto or below the ground surface. The regulations that apply are as follow:

A. New Mexico State Water Quality Standards for Interstate and Intrastate Streams (as adopted by the New Mexico Water Quality Control Commission under the New Mexico Water Quality Act, Chapter 326, Laws of 1973, as amended).

B. New Mexico State Water Quality Control Commission Regulations for discharge onto or below the surface of the ground (authorized under the New Mexico Water Quality Act, Chapter 326, Laws of 1973, as amended January 11, 1977).

C. Federal Water Pollution Control Act (FWPCA) Amendments of 1972 (6 Stat. 816 et seq., Public Law 92-500, 33 USC 1251 et seq. - Section 402 and Section 208).

D. Federal Office of Surface Mining Reclamation and Enforcement Permanent Regulatory Program as presented in the Federal Register March 15, 1979, Vol. 44, No. 50, Part II, pages 15311-15463 (as required by title V of Federal Surface Mining Control and Reclamation Act of 1977, Public Law 95-87, 30 USC 1201, 91 stat. 445).

E. National Interim Primary Drinking Water Regulations (pursuant to the section 1412 of the Public Health Service Act as amended by the Safe Drinking Water Act, Public Law 93-523, 40 FR 11990).

A summary of pertinent provisions of these water-quality regulations with respect to the study area are contained in table S-9.

The Federal Surface Mining Reclamation Act states that any mining practice should comply with the most stringent water-quality regulation to mining. The average water quality values for major chemical constitutents, trace elements, and physical measurements for surface-water and ground water supplies at or near the study area are presented in tables S-3 through S-8. These values are assumed to be representative of the natural water quality conditions in the area. Any use or disturbance of the natural surface or ground water system will tend to degrade the water quality from these natural levels.

The degree of change will be dependent on the specific mining practice. The water quality of the natural water supplies without any changes introduced by mining may or may not meet numerical standards set by the different regulations if they were subject to the regulations. Tables L-1 and L-2 present compliance of natural surface and ground water supplies to the different regulations based on the water quality values given in table S-9.

Legal interpretations may be needed to determine if flow in the ephemeral channel of the Kimbeto study area must comply with the New Mexico State Water

Quality Stream Standards, the Federal Water Pollution Control Act's NPDES, or the Federal Office of Surface Mining Reclamation and Enforcement Act. If any of the above regulations would not apply, then the New Mexico State Water Quality Control Commission Regulations for discharges onto or below the surface of the ground would apply. The National Interim Primary Drinking Water Regulations would apply only to waters used as a community drinking water supply.

Water supply

Irrigation will be required to establish vegetation within a reasonable time on reclaimed spoil piles at the Kimbeto EMRIA study area because of: (1) low annual precipitation and (2) variability of precipitation from year to year. Irrigation water may be supplied from impoundments of surface runoffs or pumpage from ground water systems. The surface runoff has lower salinity; however, its quantity is limited and varies from year to year and always contains high suspended-sediment concentrations. If surface runoff is used for reclamation, supplemental irrigation supplies will be needed and could be developed from any of several deep aquifers. Water quality of the deep aquifers will be the critical factor, but no water quality information will be available at the study area until the aquifers in the Cliff House Sandstone, Menefee Formation, and Morrison Formation are drilled, developed, tested, and analyzed for water quality. It is probable that ground water will have to be blended with surface runoff in order to become a suitable irrigation supply.

Uniform redistribution of sandy material found in sandy dunes and mesas, including "topsoiling" areas which were badlands prior to mining, may have a beneficial effect on the quality of surface flow. Surface flows originating from barren badlands tend to be more saline and contain much higher concentrations of suspended sediment than surface flow draining sandy vegetated areas. The shales of the badlands are more susceptible to chemical weathering than the stable sand grains. Topping the reclaimed areas with sandy soil will cover these shales and may reduce the potential for runoff with higher salinity and suspended sediment.

Table L-1

Compliance of Natural Surface Waters
in the Kimbeto Study Area to Water Quality Regulations

	Major constituents	Trace elements		Physical measurements
		Total	Dissolved	
New Mexico State stream standards	Yes	No for As, Cd, Cr, Hg	Yes	May not for suspended sediment, turbidity
New Mexico State discharge regulations	Yes	No for As, Ba, Cd, Cr, Fe, Mn, Hg	Yes	Yes
Federal Water Pollution Control Act (NPDES)	Yes	Set by permit	Yes	Set by permit, may not for suspended sediment
Federal Surface Mining Control and Reclamation	Yes	No for As, Ba, Cd, Cr, Pb, Hg Fe, Mn	Yes	No for suspended sediment, turbidity
Federal Drinking Water Standards	Yes	No for As, Ba, Cd, Cr, Pb, Hg	Yes	No for turbidity

Table L-2

Compliance of Natural Ground Waters
in the Kimbeto Study Area to Water Quality Regulations

	Major constituents	Trace elements		Physical measurements
		Total	Dissolved	
New Mexico State stream standards	May not for dissolved solids	NA*	Yes	May not for pH, COD, temperature
New Mexico State discharge regulations	No for Cl, SO_4	NA	May not for B	May not for pH
Federal Water Pollution Control Act (NPEDS)	Set by permit	NA	Set by permit	Set by permit
Federal Surface Mining Control and Reclamation	May not for dissolved solids	NA	May not for B, Ba	May not for pH, COD, temperature
Federal Drinking Water Standards	May not for dissolved solids, Na, F, SO_4	NA	May not for Ba	May not for pH

*NA = Not applicable

SECTION M

REFERENCES

SECTION M

REFERENCES

Climate

Blaney, Harry F., and Hanson, Eldon G., State Engineer Office, 1965, Consumptive Use and Water Requirements in New Mexico (Technical Report No. 32).

Maker, H.J., Keetch, C.W., and Anderson, J.U., New Mexico State University, Agricultural Experiment Station, June 1973, Soil Associations and Land Classification for Irrigation, San Juan County (Research Report 257).

National Oceanographic and Atmospheric Administration, various dates, Climatological Data, New Mexico.

State Engineer Office, 1956, Climatological Summary, New Mexico (Technical Reports Nos. 5 and 6).

State Engineer Office, 1976, New Mexico State Water Plan.

U.S. Bureau of Reclamation, Upper Colorado River Regional Office, July 1974, Draft Environmental Statement 74-77, Proposed El Paso Coal Gasification Project, New Mexico.

U.S. Department of Commerce, May 1961, Rainfall Frequency Atlas of the United States (Technical Paper No. 40).

Coal Resources

American Society for Testing and Materials, 1978, Standard specifications for Classification of coals by rank (ASTM designation D-388-77): 1978 Annual Book of ASTM Standards, Pt. 26, 220-224.

Averitt, Paul, 1975, Coal resources of the United States, January 1, 1974: U.S. Geol. Survey Bull. 1412, 131 p.

Cohen, A. C., 1959, Simplified estimators for the normal distribution when samples are singly censored or truncated: Technometrics, v. 1, no. 3, p. 217-237.

Connor, J. J., Keith, J. R., and Anderson, B. M., 1976, Trace-metal variation in soils and sagebrush in the Powder River basin, Wyoming and Montana: U.S. Geol. Survey Journal of Research, v. 4, no. 1, p. 49-59.

DeCarlo, J. A., Sheridan, E. T., and Murphy, Z. E., 1966, Sulfur content of United States coals: U.S. Bureau of Mines Inf. Circ. 8312, 44 p.

Fieldner, A. C., Rice, W. E., and Moran, H. E., 1942, Typical analyses of coals of the United States: U.S. Bureau Mines Bull. 446, 45 p.

Francis, Wilfried, 1961, Coal its formation and composition: London, Edward Arnold (Publishers) Ltd., 806 p.

Hatch, J. R., and Swanson, V. E., 1977, Trace elements in Rocky Mountain coals, in Murray, D. K., ed., Geology of Rocky Mountain coal--A symposium: Colorado Geological Survey Resource Series 1, p. 143-165.

Lowry, H. H., ed., 1945, Chemistry of coal utilization, Volumes I and II: New York, John Wiley and Sons, Inc., 1968 p.

_____1963, Chemistry of coal utilization, supplementary volume: New York, John Wiley and Sons, Inc., 1142 p.

Miesch, A. T., 1967, Methods of compution for estimating geochemical abundances: U.S. Geol. Survey Prof. Paper 574-B, 15 p.

Moore, E. S., 1940, Coal, its properties, analysis, classification, geology, extraction, uses and distribution: New York, John Wiley and Sons, Inc. 473 p.

Schneider, G. B., 1978, Preliminary Geologic Map of the Kimbeto EMRIA Study Site Area, Kimbeto, Sargent Ranch, Pueblo Bonito, and Pueblo Bonito NW Quadrangles, San Juan County, New Mexico: U.S. Geol. Survey Open-File Report 78-90, 1 pl.

Schopf, J. M., 1960, Field description and sampling of coal beds: U.S. Geol. Survey Bull. 1111-B, 70 p.

_____1966, Definitions of peat and coal and of graphite that terminates the coal series (Graphocite): Journ. Geology, v. 74, no. 5, pt. 1, p. 584-592.

Snyder, N. H., 1950, Handbook on coal sampling: U.S. Bureau Mines Tech. Paper 133 (revised), 10 p.

Swanson, V. E., and Huffman, Claude, Jr., 1976, Guidelines for sample collecting and analytical methods used in the U.S. Geological Survey for determining chemical composition of coal: U.S. Geol. Survey Circ. 735, 11 p.

Swanson, V. E., Medlin, J. H., Hatch, J. R., Coleman, S. L., Wood, G. H., Jr., Woodruff, S. D., and Hildebrand, R. T., 1976, Collection, chemical analysis and evaluations of coal samples in 1975: U.S. Geol. Survey Open-File Report 76-468, 503 p.

Tomkeieff, S. I., 1954, Coals and bitumens and related fossil carbonaceous substances: London, Pergamon Press Ltd., 122 p.

U. S. Bureau of Mines, 1965, Bituminous coal, in Mineral facts and problems 1965; p. 119-147.

Hydrology and Water Supply

Lyford, Forest P., 1979, Ground water in the San Juan Basin, New Mexico and Colorado: Water Resources Investigations 79-73, 22 p.

Scott, A. G., and Kunkler, J. L., 1976, Flood discharges of streams in New Mexico as related to channel geometry: U.S. Geol. Survey open-file report 76-414, 29 p.

Surface Mining Control and Reclamation Act of 1977, Public Law 95-87 Aug. 3, 1977, 30 USC 1201, 91 Stat. 445-532.

U.S. Department of Agriculture, 1954, Diagnosis and Improvement of Saline and Alkali Soils: Agriculture Handbook No. 60, pp. 79-82.

Land and Overburden Material

Cook, C. W., Hyde, R. M., and Sims, P. L., 1974, Revegetation Guidelines for Surface Mined Areas. CSU Range Sci. Dept. Science Series No. 16.

Diagnosis and Improvement of Saline and Alkali Soils, USDA Handbook No. 60, Richards, L. A., 1954.

New Mexico Range Plants--New Mexico State University Cooperative Extension Service, Circular 374, 1970.

New Mexico State University, Agricultural Experiment Station, Research Report 257, 1973.

Rai, D., Wierenga, P. J., and Gould, W. L., 1974. Chemical and Physical Properties of Core Samples from Coal Bearing Formation in San Juan County, New Mexico. New Mexico State Univ. Ag. Exp. Station Res. Report 287.

Rehabilitation of Disturbed Lands by Berg, W. A., 1975, Agronomy Dept. CSU.

Restoring Surface-Mined Lands--U.S. Department of Agriculture Miscellaneous Pub. No. 1082, 1968.

Soil Survey Manual, USDA Handbook No. 18, 1971.

Staff, Soil Survey, Soil Classification, A Comprehensive System, Seventh Approximation, with supplements: 1960 Soil Conservation Service, U.S. Department of Agriculture.

Overburden Geochemistry

Erdman, J. A., Ebens, R. J., and Case, A. A., 1978, Molybdenosis: a potential problem in ruminants grazing on coal-mine spoils. J. Range Manage. 31:34-36.

Hinkley, Todd K., Herring, J. R., and Ebens, R. J., 1980; Chemical Character and Practical pre-Mining Sampling Needs, Fort Union Formation Coal Overburden Rock, in Carter, Lorna M., ed., Proceedings of the Fourth Symposium on the Geology of Rocky Mountain Coal - 1980, Colorado Geological Survey Department of Natural Resources State of Colorado, Denver, Co. pp. 45-40.

Hinkley, Todd K., Ebens, R. J., and Boerngen, Josephine G., 1978, Overburden chemistry and mineralogy at Hanging Woman Creek, Big Horn County, Montana and recommendations for sampling at similar sites: U.S. Geological Survey Open-File Report 78-393, 58 p.

Physiography, Relief, and Drainage; Geology

Baltz, Elmer H., 1967, Stratigraphy and Regional Tectonic Implications of Part of Upper Cretaceous and Tertiary Rocks, East Central San Juan Basin, New Mexico: Geol. Survey Prof. Paper 552.

Dane, C. H., and Bachman, G. O., 1957, Preliminary Geologic Map of the Northeastern Part of New Mexico: U.S. Geol. Survey Misc. Geol. Inv. Map I-224.

Kelley, V. C., 1950, Regional Structure of the San Juan Basin: New Mexico Geol. Soc. Guidebook, 1st Field Conference, San Juan Basin, New Mexico and Colorado: p. 101-108.

Sears, Julian D., 1934, Geology and Fuel Resources of the Southern Part of the San Juan Basin, New Mexico: Geol. Survey Bulletin 860-A, Part 1.

Shomaker, J. W., Beaumont, E. C., and Kottlowski, F. E., 1971, Strippable Low-Sulphur Coal Resources of the San Juan Basin in New Mexico and Colorado: Memoir No. 25, New Mexico Bureau of Mines and Mineral Resources.

Silver, Caswell, 1950, The Occurrences of Gas in the Cretaceous Rocks of the San Juan Basin, New Mexico and Colorado: New Mexico Geol. Soc. Guidebook, 1st Field Conference, San Juan Basin, New Mexico and Colorado: p. 109-123.

Silver, Caswell, 1951, Cretaceous Stratigraphy of the San Juan Basin, New Mexico Geol. Soc. Guidebook, 2nd Field Conference, South and West Sides of the San Juan Basin, New Mexico and Arizona: p. 104-118.

Sediment Yields

Branson, F. A., Miller, R. F., and McQueen, I. S., 1966, Contour furrowing, pitting and ripping on rangelands of the western United States: Journal of Range Management, v. 19, p. 182-190.

Frickel, D. G., Shown, L. M., Patton, P. C., 1975, An evaluation of hillslope and channel erosion in the Piceance Basin, Colorado: Colorado Water Resources Circular 30, 37 p.

Pacific Southwest Inter-agency Committee, 1968, Report on factors affecting sediment yield in the Pacific Southwest area: Water Management Subcommittee, Sedimentation Task Force, 10 p.

Shown, L. M., 1970, Evaluation of a method for estimating sediment yield: U.S. Geological Survey Professional Paper 700-B, p. B245-B249.

Strahler, A. N., 1952, Dynamic basis of geomorphology: Geological Society of America Bulletin 63, p. 923-938.

McQueen, I. S., and Miller, R. F., 1968, Calibration and evaluation of a wide-range gravimetric method for measuring moisture stress: Soil Science, v. 106, p. 225-231.

McQueen, I. S., and Miller, R. F., 1974, Approximating soil moisture characteristics from limited data: empirical evidence and tentative model: Water Resources Research, v. 10, no. 3, p. 521-529.

Michurin, B. N., and Lytayev, I. A., 1967, Relationship between moisture content, moisture tension, and specific surface area in soil: Soviet Soil Science, v. 8, p. 1093-1103.

Miller, R. F., and McQueen, I. S., August 1978, Moisture relations in rangelands, western United States: Transactions of the First International Rangeland Congress, Denver, Colorado, p. 318-321.

Schnieder, G. B., Weide, D. L., Mytton, J. W., and Scott, G. R., 1979, Geologic Map of the Pueblo Bonito NW Quadrangle, San Juan County, New Mexico: U.S. Geological Survey Miscellaneous Field Studies Map MF-1117, scale 1:24,000, 1 sheet.

SECTION N

GEOLOGY APPENDIX

7-1337 (6-74)
Bureau of Reclamation

GEOLOGIC LOG OF DRILL HOLE

FEATURE Kimbeto Study Site PROJECT EMRIA STATE New Mexico

HOLE NO. DH-1K LOCATION San Juan County GROUND ELEV. 6,245.4' DIP (ANGLE FROM HORIZ.) 90 degrees

COORDS. N. E. TOTAL DEPTH 300.5'

BEGUN 6-1-77 FINISHED 6-9-77 DEPTH OF OVERBURDEN 9.0' BEARING

DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED 73' 6-10-77 LOGGED BY Luis Cabrera LOG REVIEWED BY J. Jackson

NOTES ON WATER LOSSES AND LEVELS, CASING, CEMENTING, CAVING, AND OTHER DRILLING CONDITIONS

Set 4" casing to 9.0', 14.8' and 26'. Classified from cuttings 0-14' and 157.8 to 164.0'.

Used 41/2" casing bit with 3-7/8" tricone pilot bit 0-9.0'; Nx wireline core barrel and diamond bit 9.0' to 157.8' and 164-300.5'; 3-7/8" tricone rock bit 157.8 to 164'.

Reamed hole with 4-1/2" diamond casing bit and 3-7/8" pilot bit from 14.8 - 26'; from 26 - 157.8 with 3-7/8" tricone rock bit from 26 - 157.8'.

Water loss (%):
0- 14.8', 0%
14.8 - 20.3, 0%
Cased hole to 14.8
20.3 - 28.4', 0%
28.4 - 58.4'; 100%
Lost water in coal zone, also lost casing seal.
58.4 - 87.9', 50%
87.9 - 109.8', 25%
Advanced casing to 26'.
109.8 - 119.3', 0%
119.3 - 300.5', 0%

TYPE AND SIZE OF HOLE	CORE RECOVERY (%)	PERCOLATION TESTS: DEPTH (FEET) FROM	TO	LOSS (G.P.M.)	PRESSURE (P.S.I.)	LENGTH OF TEST (MIN.)	ELEVATION (FEET)	DEPTH (FEET)	GRAPHIC LOG	SAMPLES FOR TESTING	CLASSIFICATION AND PHYSICAL CONDITION
4½"		Coring Time (Mins.)						1.0'			0 - 1.0': Silty sand, clayey; soft; tan. SM.
								4.5'			1 - 4.5': Clay, silty, sandy, carbonaceous. 4 - 4.5', firm; brown. CL.
	1%		10					9.0'			4.5 - 9.0': Sand, fine, silty; uncemented; firm; tan. SM.
	73%		20					14.0'			No recovery. Silty carbonaceous material with coal and sand; black.
	100		35					22.8'			14.0- 22.8': Shale, clayey, silty, few carbonaceous laminae; poorly fissile to blocky; compact, easily gouged with knife; 30-60 degree slickensides; brown yellow brown; many Fe stains.
			28.4	X blocked barrel.				25.8'			22.8 - 25.8': Siltstone, fine sandy; laminated carbonaceous seam 25.7 - 25.8'; lightly cemented, moderately hard; brown; tan and gray. Gypsum filled seam -1/8" at 23.2'.
Nx	100		30					33.8'			25.8 - 33.8': Coal
	95		50					40.8'			33.8 - 40.8': Shale, silty; clayey 38.4-40.8; carbonaceous 33.8 - 34'; poorly fissile 33.8 - 38.4'; compact, grooved easily with knife; jointed and slickensided; dark to greenish gray; absorbs water readily.
	92		45					43.4'			40.8 - 43.4': Siltstone, fine sandy, shaly; laminated; 42.4 - 43.4' moderately hard, easily scratched with knife; dark gray to gray.
	100		30					48.4'			43.4 - 48.4': Shale, clayey; grades to silty shale 45.2 - 46.9'; slightly carbonaceous 46.9 - 48.4'; some carbonaceous inclusions 43.9 - 45.2'; compact; jointed and slickensided; dark gray; black.
				X blocked in barrel				50.9'			48.4 - 50.9': Coal, silty; black.
	100		15					53.9'			50.9 - 53.9': Shale, silty to fine sandy, laminae; few coal seams 50.9 - 51.4'; poorly fissile; compact; easily gouged with knife; dark gray.
	100		25					62.2'			53.9 - 62.2': Sandstone, fine grained, silty; trace clay; laminated; friable; massive; shaly partings; tan; 75 degree joint at 55'.
	100		25					65.7'			62.2 - 65.7': Coal.
								67.7'			
								80.9'			
								83.4'			
								85.1'			
								94.5'			
								98.9'			

EXPLANATION

CORE LOSS

CORE RECOVERY

Type of hole . . . . . D = Diamond, H = Haystellite, S = Shot, C = Churn
Hole sealed . . . . . P = Packer, Cm = Cemented, Cs = Bottom of casing
Approx. size of hole (X-series) . . Ex = 1-1/2", Ax = 1-7/8", Bx = 2-3/8", Nx = 3"
Approx. size of core (X-series) . . Ex = 7/8", Ax = 1-1/8", Bx = 1-5/8", Nx = 2-1/8"
Outside dia. of casing (X-series). Ex = 1-13/16", Ax = 2-1/4", Bx = 2-7/8", Nx = 3-1/2"
Inside dia. of casing (X-series) . . Ex = 1-1/2", Ax = 1-29/32", Bx = 2-3/8", Nx = 3"

* GPO 778-404

GEOLOGIC LOG OF DRILL HOLE

FEATURE: Kimbeto Study Site | PROJECT: EMRIA | STATE: New Mexico
HOLE NO.: DH-1K | LOCATION: San Juan County | GROUND ELEV.: 6,245.4' | DIP (ANGLE FROM HORIZ.): 90 degrees
COORDS. N. ... E. ...
BEGUN: 6-1-77 | FINISHED: 6-9-77 | DEPTH OF OVERBURDEN: 9.0' | TOTAL DEPTH: 300.5' | BEARING:
DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED: 73' 6-10-77 | LOGGED BY: Luis Cabrera | LOG REVIEWED BY: J. Jackson

NOTES ON WATER LOSSES AND LEVELS, CASING, CEMENTING, CAVING, AND OTHER DRILLING CONDITIONS	TYPE AND SIZE OF HOLE	CORE RECOVERY (%)	PERCOLATION TESTS: DEPTH (FEET)	LOSS (G.P.M.)	PRESSURE (P.S.I.)	LENGTH OF TEST (MIN.)	ELEVATION (FEET)	DEPTH (FEET)	GRAPHIC LOG	SAMPLES FOR TESTING	CLASSIFICATION AND PHYSICAL CONDITION
Core breaks into .4 to 1.6' pieces 14.8 - 48.4', one piece from 50.9 - 53.0; 1' to 3.9' pieces from 53.9 - 62.2' and 65.7' - 81.9'; 1.1 - 1.8' pieces from 83.4 - 94.5'; .3' to 1.1' pieces 94.5 to 116.1; Coal from 116.1 to 125.5' broken along fracture and by drill action. Core breaks into 5 to 10' pieces with few .4 to 1' from 125.5 - 157.8'; .4 to 4' from 164 - 188.5', broke by drill action along bedding 119.6 - 300.5'. Driller reported packed barrel.	Nx	100	40 to 50	X Dropped core in hole. Recovered all core.				101.3 105.4 108.6 116.1 125.5 127.5 129.3 159.0 161.0 180.8 192.5 197.4 198.6 199.6			65.7 - 67.7': Siltstone, fine sandy, shaly to laminated; some coal streaks; moderately hard; dark gray. 67.7 - 81.9': Sandstone, fine grained, silty; laminated 67.7 - 70.4'; with shale pebbles and few carbon streaks 81.4 - 83.6'; moderate to lightly cemented 71.5 - 81.9'; friable; tan to light gray. 81.9 - 83.4': Coal, shaly contacts in top and bottom; black. 83.4 - 85.1': Shale, silty, clayey; poorly fissile; compact; few joints; dark gray to green. 85.1 - 94.5': Sandstone, fine grained, silty, seamy silty irregular laminae; shaly 88.2 - 88.7' moderately cemented limy, massive; light gray with dark seams; scratched with moderate knife pressure. 94.5 - 98.9': Shale, clayey, silty; poorly fissile; compact; grades to silty shale 97.7 - 98.9'; dark gray; 45-60 degrees compaction joints; weak HCl reaction. 98.9 - 101.3': Sandstone, fine grained, silty; irregular laminae moderately cemented; light to dark gray; scratched easily with knife. 101.3 - 105.4': Shale, clayey, silty; laminated; fissile; weak to moderate HCl reaction; compact; dark gray. 105.4 - 106': Sandstone fine grained, silty; cemented; moderately hard; light gray. 106 - 108.6': Coal 108.6 - 116.1': Shale, clayey, silty; many carbonaceous inclusions and seams; poorly fissile; compact; cuts easily with moderate knife pressure; dark gray to black; some 30-60 degree slickensided joints. Absorbs water readily. 116.1 - 125.5': Coal 125.5 - 127.5': Shale, silty, clayey, carbonaceous; few coal inclusions; poorly fissile; compact; dark gray.
	3-7/8 Nx	100	50 to 60	X blocked in barrel							
		99	55 to 60								
		95	35 to 50								
		100	50 to 60								

EXPLANATION

CORE LOSS
CORE RECOVERY

Type of hole . . . . . D = Diamond, H = Haystellite, S = Shot, C = Churn
Hole sealed . . . . . P = Packer, Cm = Cemented, Cs = Bottom of casing
Approx. size of hole (X-series) . . Ex = 1-1/2", Ax = 1-7/8", Bx = 2-3/8", Nx = 3"
Approx. size of core (X-series) . . Ex = 7/8", Ax = 1-1/8", Bx = 1-5/8", Nx – 2-1/8"
Outside dia. of casing (X-series). Ex = 1-13/16", Ax = 2-1/4", Bx = 2-7/8", Nx = 3-1/2"
Inside dia. of casing (X-series). . Ex = 1-1/2", Ax = 1-29/32", Bx = 2-3/8", Nx = 3"

7-1837 (6-74)
Bureau of Reclamation

GEOLOGIC LOG OF DRILL HOLE

FEATURE . Kimbeto Study Site . . . . . PROJECT . EMBIA . . . . . STATE . New Mexico . . . . .

HOLE NO. DH-1K LOCATION . San Juan County . . . . . GROUND ELEV. . 6,245.4' . . . . . DIP (ANGLE FROM HORIZ.) . 90 degrees . . . . .

BEGUN . 6-1-77 . . . . FINISHED . 6-9-77 . . . . DEPTH OF OVERBURDEN . 9.0' . . . . . TOTAL DEPTH . 300.5' . . . BEARING . . . . . .

DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED . . . . 73' . . 6-10-77 . . . . . LOGGED BY . Luis Cabrera . . . . . LOG REVIEWED BY . J. Jackson . . . . . .

NOTES ON WATER LOSSES AND LEVELS, CASING, CEMENTING, CAVING, AND OTHER DRILLING CONDITIONS	TYPE AND SIZE OF HOLE	CORE RECOVERY (%)	PERCOLATION TESTS: DEPTH (FEET) FROM	TO	LOSS (G.P.M.)	PRESSURE (P.S.I.)	LENGTH OF TEST (MIN.)	ELEVATION (FEET)	DEPTH (FEET)	GRAPHIC LOG	SAMPLES FOR TESTING	CLASSIFICATION AND PHYSICAL CONDITION
Water Level Data: Hole @ W.L. Date 48.5' 33' 6-2 300.5' 73' 6-10 Flushed hole with clear water at 300.5' 6/9/77. Pulled drill rods for Geophysical logging. Placed 1¼" PVC pipe from 0-300' with lower 120' perforated with 1/8" holes; placed rubber plug at 176' and cemented hole from 176-170'. Pulled 4" casing. Completed DH-1K.	Nx		200.5									
		92	15									
	210								10			
		91	15									
	220								221.0' 20			
		100	10									
	230								30			
		100	50						236.5'			
	240								241.8' 40			
		100	40									
	250								50			
		100	60						255.0'			
									257.5'			
	260								60			
		100	65									
	270								70			
		100	50									
	280								80			
		100	65									
	290								90			
		100	30									
		100	30									
									300.5'			

127.5 - 129.8': Sandstone, very fine grained, silty; few to many shaly laminae. 128.6 - 129.8', moderately cemented; light to dark gray.

129.8 - 159.0': Sandstone, fine grained, small amount medium; silty; lightly to moderately cemented; friable; crushes to 1/4" fragments with medium finger pressure; light gray to brown; with dark gray, fissile, silty shale, from 130.9 - 131.4'; dark gray sandy siltstone inclssions (-3") at 138' and .1' seam at 146.7'; scattered shale pepbles (shale) 145.8 - 146.8'. (Cuttings from 157.8 - 159').

159 - 161': Cuttings. Mostly carbonaceous shale; coal with sandstone.

161 - 180.5': Sandstone, very fine to fine grained, silty, slightly clayey, 171 - 173.4'; with clayey siltstone 170.5 - 171' and 173.4 - 173.8'; dense moderately hard; friable; cuts easily with knife; light to grayish green.

180.5 - 192.5': Siltstone, fine sandy, slightly clayey, laminated; shaly 186.9 - 188.5', dense, moderately hard, greenish gray; grades from 188.5 - 188.9' and 189.6 - 190.8' to shale, clayey, silty, poorly fissile, dark gray; weak HCl reaction 184.9 - 192.5'.

192.5 - 197.4': Shale, clayey silty; poorly fissile with some silty shale laminations; compact; slakes; dark to greenish gray.

197.4 - 198.6': Sandstone, very fine grained, silty; friable; light greenish gray.

198.6 - 199.6': Shale, same as 192.5 - 197.4'.

199.6 - 221': Sandstone, fine to very fine grained, silty; shaly partings; moderately to slightly cemented 203.1-221'; grades from 204.7 - 205.3, 218.4-218.8' and 219.5 - 220.1' to shale; clayey, silty, with silty laminae; poorly fissile; compact to moderately hard seams; light greenish gray to dark gray.

EXPLANATION

CORE LOSS

CORE RECOVERY

Type of hole	D = Diamond, H = Haystellite, S = Shot, C = Churn			
Hole sealed	P = Packer, Cm = Cemented, Cs = Bottom of casing			
Approx. size of hole (X-series) . .	Ex = 1-1/2'',	Ax = 1-7/8'',	Bx = 2-3/8'',	Nx = 3''
Approx. size of core (X-series) . .	Ex = 7/8''	Ax = 1-1/8''	Bx = 1-5/8'',	Nx – 2-1/8''
Outside dia. of casing (X-series).	Ex = 1-13/16'',	Ax = 2-1/4'',	Bx = 2-7/8'',	Nx = 3-1/2''
Inside dia. of casing (X-series). .	Ex = 1-1/2'',	Ax = 1-29/32'',	Bx = 2-3/8'',	Nx = 3''

* GPO 778-404

7-1887 (6-74)
Bureau of Reclamation

GEOLOGIC LOG OF DRILL HOLE

FEATURE: Kimbeto Study Site — PROJECT: EMRIA — STATE: New Mexico

HOLE NO.: DH-1K — LOCATION: San Juan County — COORDS. N. ..... E. ..... — GROUND ELEV.: 6,245.4' — DIP (ANGLE FROM HORIZ.): 90 degrees

BEGUN: 6-1-77 — FINISHED: 6-9-77 — DEPTH OF OVERBURDEN: 9.0' — TOTAL DEPTH: 300.5' — BEARING: .....

DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED: 73' 6-10-77 — LOGGED BY: Luis Cabrera — LOG REVIEWED BY: J. Jackson

NOTES ON WATER LOSSES AND LEVELS, CASING, CEMENTING, CAVING, AND OTHER DRILLING CONDITIONS	TYPE AND SIZE OF HOLE	CORE RECOVERY (%)	PERCOLATION TESTS: DEPTH (FEET) FROM (P, Cs, or Cm)	PERCOLATION TESTS: DEPTH (FEET) TO	PERCOLATION TESTS: LOSS (G.P.M.)	PERCOLATION TESTS: PRESSURE (P.S.I.)	PERCOLATION TESTS: LENGTH OF TEST (MIN.)	ELEVATION (FEET)	DEPTH (FEET)	GRAPHIC LOG	SAMPLES FOR TESTING	CLASSIFICATION AND PHYSICAL CONDITION
									10			221 - 236.5': Shale, clayey, silty; fissile; compact; with some irregular siltstone laminae and seams (1/4" to 3") closely spaced to .5' apart; sandy, 234.2 - 236.5'; highly cemented light to dark gray. Shale cuts easily with knife.
									20			236.5 - 241.8': Sandstone, very fine to fine grained; silty; lightly cemented; cut easily with medium knife pressure; grades from 237.6 - 237.8', 238.7 - 238.9', 239.1 - 239.3' and 239.7 - 240.1' to clayey shale; fissile; compace; dark gray; slakes.
									30			241.8 - 255.0': Siltstone, very fine sandy; laminae and cross laminae; numerous silty clayey shale seams (1/4" to 5'); fissile; moderately hard to compact; light to dark gray; shale slakes.
									40			255 - 257.5': Shale, clayey, silty, few siltstone irregular seams (-1 1/2"); grades from 272 - 272.7 to shaly partings; light to dark gray. Cuts easily with knife.
									50			257.5 - 260.5': Sandstone, fine grained, silty, dense, laminated, shaly partings, light to greenish gray.
									60			260.6 - 300.5': Shale, clayey, silty, traces of pyrite, fissile, poorly developed in parts, with many siltstone laminations, pebbles and seams (-1¼") grades from 272 - 272.7' to shaly partings, light to dark gray. Cuts easily with knife.
									70			
									80			
									90			

EXPLANATION

CORE LOSS

CORE RECOVERY

Type of hole . . . . . D = Diamond, H = Haystellite, S = Shot, C = Churn
Hole sealed . . . . . P = Packer, Cm = Cemented, Cs = Bottom of casing

Approx. size of hole (X-series)	Ex = 1-1/2",	Ax = 1-7/8",	Bx = 2-3/8",	Nx = 3"
Approx. size of core (X-series)	Ex = 7/8",	Ax = 1-1/8",	Bx = 1-5/8",	Nx – 2-1/8"
Outside dia. of casing (X-series)	Ex = 1-13/16",	Ax = 2-1/4",	Bx = 2-7/8",	Nx = 3-1/2"
Inside dia. of casing (X-series)	Ex = 1-1/2",	Ax = 1-29/32",	Bx = 2-3/8",	Nx = 3"

* GPO 778-404

7-1337 (6-74)
Bureau of Reclamation

GEOLOGIC LOG OF DRILL HOLE

SHEET. . 1 . . OF . 3 . . .

FEATURE . Kimbeto Study Site . . . . . PROJECT . . EMRIA . . . . . STATE . New Mexico . . . . . .

HOLE NO. DH-2K . . . . LOCATION . . San Juan County . . . . . GROUND ELEV. . 6,287.0' . . . . . DIP (ANGLE FROM HORIZ.) 90. degrees . . . . . .

BEGUN . 5-18-77 . . . . . FINISHED. 5-31-77 . . . DEPTH OF OVERBURDEN . 2.0' . . . . . TOTAL DEPTH . 225.0' . . . BEARING . . . . . .

DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED . . See Notes . . . . . LOGGED BY . . Luis Cabrera . . . . . LOG REVIEWED BY . J. L. Jackson . . . . . .

NOTES ON WATER LOSSES AND LEVELS, CASING, CEMENTING, CAVING, AND OTHER DRILLING CONDITIONS	TYPE AND SIZE OF HOLE	CORE RECOVERY (%)	PERCOLATION TESTS: DEPTH (FEET) FROM (P, Cs, or Cm)	DEPTH (FEET) TO	PERCOLATION TESTS: LOSS (G.P.M.)	PERCOLATION TESTS: PRESSURE (P.S.I.)	PERCOLATION TESTS: LENGTH OF TEST (MIN.)	ELEVATION (FEET)	DEPTH (FEET)	GRAPHIC LOG	SAMPLES FOR TESTING	CLASSIFICATION AND PHYSICAL CONDITION
Set 4" casing to 4.0' and 20.0'. Used 4½" casing bit with 3-7/8" tri-cone pilot bit from 0 - 4.5'; Nx 10-foot wire-line core barrel and diamond bit 4.5' to 225.0'. 0 - 4.5': Classified from cuttings. Soft drilling 0-2'. Firm drilling 2 - 4.5'. Water Loss: 0 - 12.0', No loss 12.0-12.5', 75% 12.5-30.8', 100% 30.8-88.6', No loss 88.6-98.2, 20% 98.2-108.4; 25% 108.4-146.9', 50% 146.9-194.2', 25% 194.2-199.2', 10% 199.2-225.0', 25% Water Level Data Hole @ W.L. Date 31.0' Dry 5-19 98.2' 78.2' 5-19 98.2' 71.0' 5-20 166.4' 74.0' 5-25 218.7' 78.0' 5-26 225.0' 80.4' 5-31	4½" Nx	90	25						2.0'			0 - 2.0': Sand, fine, silty, slightly clayey; soft; tan; SM-SC. 2.0 - 22.5': Shale, clayey, silty; Fe stained; poorly fissile to blocky; compact; jointed; breaks easily along bedding planes and joints; grades from 5.0 - 7.5', 9.5 - 10.5', 12.0 - 13.8', 17.3 - 18.0' and 18.5 - 19.4' to silty shale; clayey; laminated; compact; yellow brown to brown and gray. Grooves easily with knife. Weathered. Slakes on drying.
		80	30		XX blocking in barrel				22.5'			
		73	20		XX blocking in barrel							22.5 - 32.6': Sandstone, fine grained; silty, silty and carbonaceous along bedding; thin beds, laminated; friable grayish tan and yellow brown. Can be scratched with fingernail.
		95	35						32.6'			32.6 - 56.7': Shale, clayey, silty; carbonaceous 32.6 - 33.2' and 54.0 - 56.7'; with coal seams -½" 32.6 - 33.2'; few gypsum veinlets; poorly fissile to blocky; jointed and slickensided, breaks easily along joints and bedding upon drying; many Fe stained; some carbon filled; grooves easily with knife; grades from 34.4 - 36.3', 39.5 - 45.3', 46.3 - 47.3' and 49.0 - 51.6' to siltstone, clayey; sandy 50.0 - 51.6'; clayey shale 50.8 - 51.0'; laminated; shaly partings; 15 - 75 degree joints, Fe stained; cuts easily with knife. Light to dark gray, brown, black.
		90	40						56.7'			
		107	40						63.0'			56.7 - 63.0': Shale, silty, clayey, with silty, fine sandstone seams (-.2'); lightly cemented; moderately hard. Can be crushed with medium finger pressure. Light to dark gray.
		100	20						77.8'			63.0 - 77.8': Sandstone, fine grained; silty; grades to sandy siltstone; shaly; friable to moderately hard, easily scratched with knife. Light to dark gray.
		106	17									
		97	15						89.6'			77.8 - 89.6': Sandstone, fine grained; silty; lightly cemented; friable, with few thin uncemented seams, to moderately hard and cemented 87.8 - 88.9'; laminated, scattered thin carbon seams; light gray. can be scratched with light to medium knife pressure.
		103	15									89.6 - 104.4': Coal.

EXPLANATION

CORE LOSS

CORE RECOVERY

Type of hole . . . . . D = Diamond, H = Haystellite, S = Shot, C = Churn
Hole sealed . . . . . P = Packer, Cm = Cemented, Cs = Bottom of casing
Approx. size of hole (X-series) . . Ex = 1-1/2", Ax = 1-7/8", Bx = 2-3/8", Nx = 3"
Approx. size of core (X-series) . . Ex = 7/8", Ax = 1-1/8", Bx = 1-5/8", Nx = 2-1/8"
Outside dia. of casing (X-series). Ex = 1-13/16", Ax = 2-1/4", Bx = 2-7/8", Nx = 3-1/2"
Inside dia. of casing (X-series). . Ex = 1-1/2", Ax = 1-29/32", Bx = 2-3/8", Nx = 3"

* GPO 778-404

7-1837 (6-74)
Bureau of Reclamation

GEOLOGIC LOG OF DRILL HOLE

FEATURE: Kimbeto Study Site — PROJECT: EMRIA — STATE: New Mexico

HOLE NO.: DH-2K — LOCATION: San Juan County — GROUND ELEV.: 6,287.0' — DIP (ANGLE FROM HORIZ.): 90 degrees

COORDS. N. ..... E. .....

BEGUN: 5-18-77 — FINISHED: 5-31-77 — DEPTH OF OVERBURDEN: 2.0' — TOTAL DEPTH: 225.0' — BEARING: .....

DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED: See Notes — LOGGED BY: Luis Cabrera — LOG REVIEWED BY: J. L. Jackson

NOTES ON WATER LOSSES AND LEVELS, CASING, CEMENTING, CAVING, AND OTHER DRILLING CONDITIONS	TYPE AND SIZE OF HOLE	CORE RECOVERY (%)	PERCOLATION TESTS: DEPTH (FEET)	PERCOLATION TESTS: TO	PERCOLATION TESTS: LOSS (G.P.M.)	PERCOLATION TESTS: PRESSURE (P.S.I.)	PERCOLATION TESTS: LENGTH OF TEST (MIN.)	ELEVATION (FEET)	DEPTH (FEET)	GRAPHIC LOG	SAMPLES FOR TESTING	CLASSIFICATION AND PHYSICAL CONDITION
Core in fine gravel size (blocky) to 0.5' lengths from 4.5 - 22.5', breaks easily upon drying; 0.2' - 1.3' lengths from 32.6 - 54.5', breaks easily on drying along joints and bedding; 0.4' - 2.8' lengths from 54.5 - 89.5', one piece 84.1 - 89.3'; 0.2' - 2.1' from 89.6 - 137.4'; ½" to .6' lengths from 137.4 - 146.9' broke by drill action, parts on drying; 0.2' - 2.4' lengths from 146.9 - 156.1'; broke by drill action 156.1-170'; 0.6' - 3.1' lengths from 170.0' - 188.9'; broke by drill action to 3/4" to .7' lengths from 188.9'- 196.2'; 0.2' - 2.6' lengths from 196.2 - 225.0'. Coal in interval 156.1 - 156.4' not bagged.			Coring Time (Mins)						104.4'		104.4 - 106.7': Shale, clayey; carbonaceous; silty laminae 106.0 - 106.7'; fissile; compact; black to dark gray.
		100	20	XX Crushed core in barrel.					106.7'			
									108.4'			106.7 - 108.4': Coal
	110	100	35						10			108.4 - 118.5': Shale, clayey to silty; irregular carbon streaks 108.4 - 109.6' and 117.0 - 117.6'; poorly fissile; compact; jointed and slickensided, 5 - 45 degrees; dark to greenish gray; cuts easily with fingernail; absorbs water readily.
									118.5'			
	120	96	40	XX Blocked.					120.4'			118.5 - 120.4': Siltstone, shaly; carbonaceous; compact; black; can be scratched with fingernail.
	130	97	45						30 132.7'			120.4 - 121.7': Sandstone, fine grained; silty; some carbonaceous and shaly laminae; moderate to hard; cemented 120.4 - 120.9'; light to dark gray.
									137.4'			
	140	102	45						40			121.7 - 132.7': Shale, clayey; silty; carbonaceous 121.7 - 124.7' and 129.6 - 132.7'; with coal seams 124.1-124.4' and 129.6 - 130.4'; poorly fissile; compact; jointed and slickensided; dark gray to black. Absorbs water readily.
	150	100	50						150.9'			
									152.9'			132.7 - 137.4': Coal
	160	100	40						60			137.4 - 150.9': Shale, clayey; silty; poorly fissile; scratches easily with fingernail; absorbs water readily; grades from 140 - 142.0' to siltstone, clayey, slightly fine, sandy; and from 146.2 - 150.9' to silty shale, clayey with many silty, fine sandstone laminations and few seams; cuts with medium knife pressure. Absorbs water readily. Light to dark gray.
									163.7'			
		100	50	XX Recovered core from previous run.. Blocking in barrel.					70			
	170	100	45						173.8'			
				XX Broke core in part.					175.4'			150.9 - 152.9': Sandstone, fine grained; many silty laminae; weakly cemented; friable; light gray.
	180	100	30						80			152.9 - 163.7': Coal, with silty shale seam 156.1 - 156.4'; fractured in parts; black.
									186.1'			
				XX Blocked.					188.4'			163.7 - 173.8': Shale, clayey; silty; carbonaceous; thin coal seams 167.2 - 168.0' and 173.6 - 173.8'; fissility poorly developed; compact; scratches easily with fingernail. Absorbs water readily; few joints and slicken-
	190	90	30	XX Blocked.					90			
		100	35						196.2'			
				XX Blocked.					200.0'			(continued)

EXPLANATION

CORE LOSS

CORE RECOVERY

Type of hole ..... D = Diamond, H = Haystellite, S = Shot, C = Churn
Hole sealed ..... P = Packer, Cm = Cemented, Cs = Bottom of casing
Approx. size of hole (X-series) .. Ex = 1-1/2", Ax = 1-7/8", Bx = 2-3/8", Nx = 3"
Approx. size of core (X-series) .. Ex = 7/8", Ax = 1-1/8", Bx = 1-5/8", Nx = 2-1/8"
Outside dia. of casing (X-series). Ex = 1-13/16", Ax = 2-1/4", Bx = 2-7/8", Nx = 3-1/2"
Inside dia. of casing (X-series).. Ex = 1-1/2", Ax = 1-29/32", Bx = 2-3/8", Nx = 3"

* GPO 778-404

7-1337 (6-74)
Bureau of Reclamation

GEOLOGIC LOG OF DRILL HOLE

FEATURE Kimbeto Study Site PROJECT EMRIA STATE New Mexico

HOLE NO. DH-2K LOCATION San Juan County

COORDS. N. E. GROUND ELEV. 6,287.0' DIP (ANGLE FROM HORIZ.) 90 degrees

BEGUN 5-18-77 FINISHED 5-31-77 DEPTH OF OVERBURDEN 2.0' TOTAL DEPTH 225.0' BEARING

DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED See Notes LOGGED BY Luis Cabrera LOG REVIEWED BY J. L. Jackson

NOTES ON WATER LOSSES AND LEVELS, CASING, CEMENTING, CAVING, AND OTHER DRILLING CONDITIONS	TYPE AND SIZE OF HOLE	CORE RECOVERY (%)	PERCOLATION TESTS: DEPTH (FEET) FROM	PERCOLATION TESTS: DEPTH (FEET) TO	PERCOLATION TESTS: LOSS (G.P.M.)	PERCOLATION TESTS: PRESSURE (P.S.I.)	PERCOLATION TESTS: LENGTH OF TEST (MIN.)	ELEVATION (FEET)	DEPTH (FEET)	GRAPHIC LOG	SAMPLES FOR TESTING	CLASSIFICATION AND PHYSICAL CONDITION
5/27/77 Hole flushed with clear water at 225.0'. Pulled rods for Geophysical logging. Hole caving in places from 90 - 127.0'. Flushed hole from 90 - 137.0' with open rods. Hole staying open below 137.0' to 217.0'. Left rods at 137.0' for Geophysical logging. Pulled rods for electric log. 5/31/77 Washed out and flushed hole with clear water from 137.0 - 213.5'. Cemented hole from 213.5 - 205.0'. Left 2.5' stickup. Pulled N rods. Pulled 4" casomg. Completed 5-31-77.		100	Coring Time (Mins) 27						206.4'			163.7 - 173.8' (continued) sides; dark to greenish gray; grades from 169.5 - 171.1' and 172.0 - 172.4' to siltstone; fine sandy seams; shaly; moderately hard; scratches easily with knife; hard, cemented 172.9 - 173.4'; light to dark gray.
									208.0'			
									208.5'			
									211.5'			
		100	20									173.8 - 175.4': Coal.
												175.4 - 186.1': Siltstone, fine sandy; laminated; shaly 175.4 - 175.7' and 184.6 - 186.1'; limy; moderately cemented, scratches with medium knife pressure; light to olive gray.
		100	15						225.0'			186.1 - 188.4': Coal, shaly 186.1 - 186.3' and 188.3 - 188.4', black.
												188.4 - 196.2': Shale, clayey; silty; compact; poorly fissile; can be scratched easily with fingernail 189.5' - 195.6'; grades to carbonaceous shale 190.0 - 190.2', 191.5 - 192.0' and 195.6 - 196.2'; and to fine sandy siltstone 188.9 - 189.5' and 190.1 - 190.7' laminated with coal seam 190.2 - 190.4' moderately hard; fractured and slickensided 188.4 - 188.9' and 189.5 - 190.1' low angle to 45 degrees 189.5 - 196.2'.
												196.2 - 206.4': Coal.
												206.4 - 208.0': Shale, silty; carbonaceous; clayey; many carbon flakes; compact; cuts easily with knife; few joints; black.
												208.0 - 208.5': Sandstone, fine grained; silty; slightly limy; moderately hard, cemented; light gray.
												208.5 - 211.5': Shale, silty; clayey; fissile; few closely spaced siltstone laminae 210.3 - 211.5'; with sandy siltstone 209.0 - 209.2'; moderately hard; can be scratched with fingernail; light to greenish gray.
												211.5 - 225.0': Sandstone, fine grained; silty; massive; laminated; many siltstone laminations 211.5 - 214.0', scattered shaly seams (~.1'); weakly cemented; can be scratched easily with knife; friable; light gray to black; grades from 218.3 - 218.6' and 219.0 - 219.6' to siltstone; clayey; shaly; moderately hard; compact; dark gray.

EXPLANATION

CORE LOSS

CORE RECOVERY

Type of hole . . . . . D = Diamond, H = Haystellite, S = Shot, C = Churn
Hole sealed . . . . . P = Packer, Cm = Cemented, Cs = Bottom of casing
Approx. size of hole (X-series) . . Ex = 1-1/2", Ax = 1-7/8", Bx = 2-3/8", Nx = 3"
Approx. size of core (X-series) . . Ex = 7/8", Ax = 1-1/8", Bx = 1-5/8", Nx = 2-1/8"
Outside dia. of casing (X-series). Ex = 1-13/16", Ax = 2-1/4", Bx = 2-7/8", Nx = 3-1/2"
Inside dia. of casing (X-series). . Ex = 1-1/2", Ax = 1-29/32", Bx = 2-3/8", Nx = 3"

* GPO 778-404

7-1887 (8-74)
Bureau of Reclamation

GEOLOGIC LOG OF DRILL HOLE

SHEET 1 OF 3

FEATURE: Kimbeto Study Site | PROJECT: EMRIA | STATE: New Mexico
HOLE NO.: DH-3K | LOCATION. COORDS. N. E. | GROUND ELEV.: 6,216.1' | DIP (ANGLE FROM HORIZ.): 90 degrees
BEGUN: 7-25-77 | FINISHED: 7-30-77 | DEPTH OF OVERBURDEN: 9.0' | TOTAL DEPTH: 252.8' | BEARING:
DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED: 20.0' 7-29-77 | LOGGED BY: W. Witt | LOG REVIEWED BY: J. Jackson

NOTES ON WATER LOSSES AND LEVELS, CASING, CEMENTING, CAVING, AND OTHER DRILLING CONDITIONS	TYPE AND SIZE OF HOLE	CORE RECOVERY (%)	PERCOLATION TESTS: DEPTH (FEET)	TO	LOSS (G.P.M.)	PRESSURE (P.S.I.)	LENGTH OF TEST (MIN.)	ELEVATION (FEET)	DEPTH (FEET)	GRAPHIC LOG	SAMPLES FOR TESTING	CLASSIFICATION AND PHYSICAL CONDITION
Set Nx Casing to 9.0'; 20'; 23'; and 25.5'. Used Nx 10-foot wireline core barrel and diamond bit 0 to 252.8'. Water Loss (%): 0 - 15.5', 0% 15.5 - 25.5', 25% 25.5 - 90.9', 0% 90.9 - 130.2', 10% 130.2 - 137.2', 0% 137.2 - 154.3', 10% 154.3 - 252.8', 0% Water Level Data Hole @ W.L. Date 15.5' dry 7-26 65.2' 15.0' 7-27 130.2' 23.0' 7-28 200.5' 20.0' 7-29 7-29-77 Pulled rods for Geophysical logging. 7-30-77 Pushed canvas sack plug to 105' with drill rods. Flushed hole clean with clear water. Cemented hole through drill rods from 105' to 80'. Set PVC pipe from 0 to 80' with 10' extension in cement. PVC pipe perforated with 1/8" port hole from 40' to 80'; placed rubber plug at 38.0'. Pulled Nx casing. Completed DH-3K		0	Coring Time (Mins.)									0' - 9.0': No recovery. Silty sand. Logged from cuttings.
		80	15						9.0'			9.0' - 14.5': Siltstone. Moderately weathered; grayish green; bedding horizontal; very intensely fractured.
									14.5'			14.5' - 26.4': Sandstone. Moderately weathered; grayish green; very intensely fractured. 19.3' - 21.2': No recovery. 19.1' - 21.5': Siltstone. Light green; very intensely fractured.
		84	20						26.4'			26.4' - 26.6': Mudstone. Red; hard; recovered in one core length.
		87	20						26.6'			26.6' - 33.0': Shale. Moderately weathered; light green; very intensely fractured. 31.2' - 33.0': Carbonaceous Shale. Lightly weathered; laminated light green and black. 33.0' - 33.6': Coal.
		98	30						33.6'			33.6' - 49.4': Siltstone. Lightly weathered; light green; intensely fractured.
		100	15						49.4'			49.4' - 54.4': Carbonaceous Shale. Lightly weathered; light green with black streaks; finely laminated.
		99	30						54.4'			54.4' - 65.6': Sandstone. Fresh; light green; fine to medium grained; near horizontally bedded; intensely to moderately fractured.
									65.6'			65.6' - 118.5': Siltstone. With 5-10% thin carbonaceous laminae; lightly weathered; bedding near horizontal; very intensely fractured. 65.8' - 66.1': Coal. 69.7' - 70.1': Coal. 78.6' - 80.1': Coal. 82.5' - 93.3': Coal. 95.2' - 97.3': Coal. 103.3' - 103.9': Coal.
		99	165						78.6'			
									82.5'			
									93.3'			
									95.2'			
									97.3'			

EXPLANATION

CORE LOSS
CORE RECOVERY

Type of hole . . . . . D = Diamond, H = Haystellite, S = Shot, C = Churn
Hole sealed . . . . . P = Packer, Cm = Cemented, Cs = Bottom of casing
Approx. size of hole (X-series) . . Ex = 1-1/2", Ax = 1-7/8", Bx = 2-3/8", Nx = 3"
Approx. size of core (X-series) . . Ex = 7/8", Ax = 1-1/8", Bx = 1-5/8", Nx = 2-1 8"
Outside dia. of casing (X-series). Ex = 1-13/16", Ax = 2-1/4", Bx = 2-7 8", Nx = 3-1 2"
Inside dia. of casing (X-series). . Ex = 1-1/2", Ax = 1-29/32", Bx = 2-3 8", Nx = 3"

* GPO 778-404

7-1937 (6-74)
Bureau of Reclamation

GEOLOGIC LOG OF DRILL HOLE

FEATURE: Kimbeto Study Site — PROJECT: EMRIA — STATE: New Mexico

HOLE NO.: DH-3K — LOCATION: San Juan County — GROUND ELEV.: 6,216.1' — DIP (ANGLE FROM HORIZ.): 90 degrees

COORDS. N. ..... E. .....

BEGUN: 7-25-77 — FINISHED: 7-30-77 — DEPTH OF OVERBURDEN: 9.0' — TOTAL DEPTH: 252.8' — BEARING:

DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED: 20.0' 7-29-77 — LOGGED BY: W. Witt — LOG REVIEWED BY: J. Jackson

NOTES ON WATER LOSSES AND LEVELS, CASING, CEMENTING, CAVING, AND OTHER DRILLING CONDITIONS	TYPE AND SIZE OF HOLE	CORE RECOVERY (%)	PERCOLATION TESTS: DEPTH (FEET)	TO	LOSS (G.P.M.)	PRESSURE (P.S.I.)	LENGTH OF TEST (MIN.)	ELEVATION (FEET)	DEPTH (FEET)	GRAPHIC LOG	SAMPLES FOR TESTING	CLASSIFICATION AND PHYSICAL CONDITION
			Coring (Rine.)						103.3' 103.9'			118.5' - 134.0': Sandstone. Fresh; limy; light greenish gray; fine to medium grained; bedding near horizontal; moderately fractured.
									118.5'			134.0' - 141.0': Coal.
		99	35						134.0'			141.0' - 143.2': Siltstone. Fresh; greenish gray; very intensely fractured.
		98	20						141.0'			143.2' - 154.3': Sandstone. Fresh; gray; fine grained with 10% thin dark gray shale beds; limy.
		72	20						143.2' 154.3'			154.3' - 161.8': Sandstone. Fresh; light gray; massive.
		84	15						161.8'			161.8' - 169.8': Coal.
		116	40						169.8'			169.8' - 176.5': Siltstone. Fresh; greenish gray, horizontal bedding; very intensely fractured.
		96	25						176.5' 177.2'			176.5' - 177.2': Mudstone. Tan; calcite healed (vuggy).
		100	45						190.6' 191.2'			177.2' - 190.6': Sandy Siltstone. Fresh; greenish gray; bedding near horizontal; hard; intensely to moderately fractured.
		106	30						196.2' 197.8' 199.0'			190.6' - 197.8': Carbonaceous Shale. Fresh; dark gray; thinly laminated; near horizontally bedded. 191.2' - 196.2': Coal. 197.8' - 199.0': Silty Shale. Dark gray; intensely to moderately fractured. 199.0' - 206.3': Sandstone. Fresh; light greenish gray; fine to medium grained; with 10% thin silt laminae.

EXPLANATION

CORE LOSS

CORE RECOVERY

Type of hole ..... D = Diamond, H = Hoystellite, S = Shot, C = Churn
Hole sealed ..... P = Packer, Cm = Cemented, Cs = Bottom of casing

Approx. size of hole (X-series)	Ex = 1-1/2",	Ax = 1-7/8",	Bx = 2-3/8", Nx = 3"
Approx. size of core (X-series)	Ex = 7/8",	Ax = 1-1/8",	Bx = 1-5/8", Nx = 2-1/8"
Outside dia. of casing (X-series)	Ex = 1-13/16",	Ax = 2-1/4",	Bx = 2-7/8", Nx = 3-1/2"
Inside dia. of casing (X-series)	Ex = 1-1/2",	Ax = 1-29/32",	Bx = 2-3/8", Nx = 3"

* GPO 778-404

7-1337 (6-74)
Bureau of Reclamation

GEOLOGIC LOG OF DRILL HOLE

SHEET 3 OF 3

FEATURE: Kimbeto Study Site | PROJECT: EMRIA | STATE: New Mexico

HOLE NO.: DH-3K | LOCATION: San Juan County | COORDS. N: E: | GROUND ELEV.: 6,216.1' | DIP (ANGLE FROM HORIZ.): 90 degrees

BEGUN: 7-25-77 | FINISHED: 7-30-77 | DEPTH OF OVERBURDEN: 9.0' | TOTAL DEPTH: 252.8' | BEARING:

DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED: | LOGGED BY: W. Witt | LOG REVIEWED BY: J. Jackson

NOTES ON WATER LOSSES AND LEVELS, CASING, CEMENTING, CAVING, AND OTHER DRILLING CONDITIONS	TYPE AND SIZE OF HOLE	CORE RECOVERY (%)	PERCOLATION TESTS: DEPTH (FEET)	TO	LOSS (G.P.M.)	PRESSURE (P.S.I.)	LENGTH OF TEST (MIN.)	ELEVATION (FEET)	DEPTH (FEET)	GRAPHIC LOG	SAMPLES FOR TESTING	CLASSIFICATION AND PHYSICAL CONDITION
		Coring Time (Mins)										
		99	20						206.3'			206.3' - 218.4': Coal.
		101	25						218.4'			218.4' - 223.8': Sandstone. Fresh; gray; medium grained; with 10% thin silt laminae.
		100	15						223.8'			223.8' - 252.8': Sandstone. Fresh; light gray; mostly massive. 223.8' - 226.0': Very intensely fractured. 251.0' - 251.5': Sandstone. Silty; dark gray.
		100	45						252.8'			

EXPLANATION

CORE LOSS

CORE RECOVERY

Type of hole . . . . . D = Diamond, H = Haystellite, S = Shot, C = Churn
Hole sealed . . . . . P = Packer, Cm = Cemented, Cs = Bottom of casing
Approx. size of hole (X-series) . . Ex = 1-1/2", Ax = 1-7/8", Bx = 2-3/8", Nx = 3"
Approx. size of core (X-series) . . Ex = 7/8", Ax = 1-1/8", Bx = 1-5/8", Nx = 2 1 8"
Outside dia. of casing (X-series). Ex = 1-13/16", Ax = 2-1/4", Bx = 2-7 8", Nx = 3-1 2"
Inside dia. of casing (X-series). . Ex = 1-1/2", Ax = 1-29/32", Bx = 2-3 8", Nx = 3"

* GPO 778-404

7-1887 (6-74)
Bureau of Reclamation

GEOLOGIC LOG OF DRILL HOLE

FEATURE: Kimbeto Study Site — PROJECT: EMRIA — STATE: New Mexico
HOLE NO.: DH-4K — LOCATION: San Juan County — GROUND ELEV.: 6,331.3' — DIP (ANGLE FROM HORIZ.): 90 degrees
BEGUN: 5-3-77 — FINISHED: 5-10-77 — DEPTH OF OVERBURDEN: 33.5' — TOTAL DEPTH: 250' — BEARING:
DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED: See Notes — LOGGED BY: Luis Cabrera — LOG REVIEWED BY: J. L. Jackson

NOTES ON WATER LOSSES AND LEVELS, CASING, CEMENTING, CAVING, AND OTHER DRILLING CONDITIONS	TYPE AND SIZE OF HOLE	CORE RECOVERY (%)	PERCOLATION TESTS: DEPTH (FEET)	TO	LOSS (G.P.M.)	PRESSURE (P.S.I.)	LENGTH OF TEST (MIN.)	ELEVATION (FEET)	DEPTH (FEET)	GRAPHIC LOG	SAMPLES FOR TESTING	CLASSIFICATION AND PHYSICAL CONDITION
Set 4" surface casing 0 - 34.7'. Used 4" casing with 4½" casing diamond bit and 3-7/8" pilot bit from 0 - 35'. Pulled 3-7/8" pilot bit and set 4" casing. Easy drilling 0 - 7'; firm drilling 7 - 33.5'; tough 33.5 - 35'. Classified from cuttings from 0 - 35'. Water Loss: 0-24', No loss 24-33.5', 20% 33.5-35.0', 5% 35-55.0', No loss 55-75.0', 20% 75-162.0', No loss 162-164.4', 25% 164.4-208.6', 50% 208.6-213.5', 25% 213.5-223.0', 20% 223.0-250.0', 5% Used 10' Nx wireline core barrel with diamond bit 35'-250'.	4½"		Coring Time (Mins.)						7.0'			0 - 7': Sand, fine, silty, uncemented, tan. SM 7 - 33.5': Sand, fine to medium, silty, uncemented, firm, tan and brown. SM 33.5 - 41.0': Shale, clayey, silty, poorly laminated, crumbly 37.3 - 39.5'; closely spaced low angle to 45 degree joints; Fe stained; grooves easily with knife; olive to yellowish brown. Slakes. 41.0 - 45.7': Siltstone, clayey, sandy, shaly in parts; few 45 degree joints, 60 degree to near vertical 43.3 - 45.2'; tan and dark gray. 45.7 - 48.0': Sandstone, fine, silty, laminated; friable; 80 degree sand filled joint; tan. 48.0 - 55.0': Siltstone, fine, sandy, clayey; carbonaceous, thin seams and .4' seam at 51.4'; 30degree - 75 degree joints, few vertical, tight to open 52.0 - 55.0; Fe stained, orange to dark brown and black seams, moderately hard but cuts easily with knife. 55.0 - 59.8': Sandstone, fine, silty, carbonaceous 56.2 - 56.8', irregular seams and inclusions of black siltstone; friable; light to dark gray; cuts easily with knife. 59.8 - 71.6': Sandstone, fine, silty, limy; weakly cemented, friable to moderately hard 64.0' - 67.0'; light gray and tan; vertical fracture at 64.2', 45 degree joint at 66.8'; scratches easily with knife. 71.6 - 81.5': Shale, clayey, silty, irregularly fissile; compact, moderately hard; silty laminations 80.2 - 81.5', scattered vertical joints; black. 81.5 - 94.8': Siltstone, shaly laminations, grades to sandy siltstone interbedded, with clayey shale seams up to .4'; moderately hard; black; and silty sandstone from 85.7 - 86.7' and 93.8 - 94.8', few fossile 93.5 - 93.7'; weakly cemented; light gray to dark gray.
									10			
									20			
									30			
									33.5'			
	Nx											
		100	45						41.0'			
									45.7'			
									48.0'			
		100	32						50			
		50	10						55.0'			
									59.8'			
		100	50						60			
			XX Blocked									
		100	20									
									70			
			XX Blocked						71.6'			
		100	15									
									80			
		100	40						81.5			
									90			
		100	55									
									94.8'			
	Ix		47									

EXPLANATION

CORE LOSS
CORE RECOVERY

Type of hole . . . . . D = Diamond, H = Haystellite, S = Shot, C = Churn
Hole sealed . . . . . P = Packer, Cm = Cemented, Cs = Bottom of casing
Approx. size of hole (X-series) . . Ex = 1-1/2", Ax = 1-7/8", Bx = 2-3/8", Nx = 3"
Approx. size of core (X-series) . . Ex = 7/8", Ax = 1-1/8", Bx = 1-5/8", Nx – 2-1/8"
Outside dia. of casing (X-series). Ex = 1-13/16", Ax = 2-1/4", Bx = 2-7/8", Nx = 3-1/2"
Inside dia. of casing (X-series) . . Ex = 1-1/2", Ax = 1-29/32", Bx = 2-3/8", Nx = 3"

* GPO 778-404

7-1837 (6-74)
Bureau of Reclamation

GEOLOGIC LOG OF DRILL HOLE

FEATURE . Kimbeto Study Site . . . . . PROJECT . EMRIA . . . . . STATE . New Mexico . . . . .

HOLE NO. . DH-4K . . . LOCATION . . San. Juan. County . . . . . GROUND ELEV. . . 6,331.3' . . . . . DIP (ANGLE FROM HORIZ.) . 90 degrees . . . . .

BEGUN . 5-3-77 . . . . FINISHED. 5-10-77 . . . . DEPTH OF OVERBURDEN . 33.5' . . . . . TOTAL DEPTH . . 250.0' . . BEARING . . . . . .

DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED . . See Notes . . . . . LOGGED BY . Luis Cabrera . . . . . LOG REVIEWED BY . . J. L. Jackson . . . . . .

NOTES ON WATER LOSSES AND LEVELS, CASING, CEMENTING, CAVING, AND OTHER DRILLING CONDITIONS	TYPE AND SIZE OF HOLE	CORE RECOVERY (%)	PERCOLATION TESTS: DEPTH (FEET) FROM	PERCOLATION TESTS: DEPTH (FEET) TO	PERCOLATION TESTS: LOSS (G.P.M.)	PERCOLATION TESTS: PRESSURE (P.S.I.)	PERCOLATION TESTS: LENGTH OF TEST (MIN.)	ELEVATION (FEET)	DEPTH (FEET)	GRAPHIC LOG	SAMPLES FOR TESTING	CLASSIFICATION AND PHYSICAL CONDITION
Water Level Data Hole W.L. Date 34.0' Dry 5-5-77 144.4' Not Measured 5-9-77 223.2' 124' 5-10-77 250.0' 124' 5-11-77 5-12-77 Hole bailed easily to 125', water level recovering slowly at 150'. Bailed to 196'. Water level recovering at rate of 9' in 5 mins. 5-12-77 Flushed hole from 70 to 237'. Pulled N rods to 190'. Hole caved back to 206'. Cemented hole from 206' to 190'. Pulled drill rods up to 187' and flushed hole clean. Pulled rods. Hole caved to 110'. Flushed hole from 110' to 237'. 2½" PVC pipe sticking in hole 59' - 110'. Pulled PVC. Hole caved to 70'.	Nx	100	Coring Time (mins.)						105.5'			94.8 - 105.5': Shale, clayey, fissile, grades to silty shale 99.3 - 105.5', carbonaceous 102.5 - 102.9'; compact, can be grooved easily with light to medium knife pressure.
									107.0'			
	110	100	40						10			105.5 - 107.0': Sandstone, fine, silty; slightly cemented, friable; light gray.
									112.3'			
			XX	Crushed in barrel.					113.5'			107.0 - 112.3': Shale, silty, clayey, poorly fissile, scattered carbon streaks; compact; slickensided joints 45 - 60 degrees; dark gray to black; grooves easily with light knife pressure.
	120	100	45						20			
			XXX	Blocked					122.0'			
		100	10									
									126.8'			
		100	45						30			112.3 - 113.5': Coal, shaly laminations; black.
	130		XX	Blocked, left 3.1' core in hole								
		100	5						134.4'			113.5 - 122.0': Shale, same as 107 - 112.3'; grades to sandstone 115.2 - 116.2', fine, silty; moderately cemented, friable; gray; and from 118.4 - 118.8' to siltstone, limy, hard; tan.
			XX	Recovered core.								
		99	20						40			
	140											
			XX	Crushed in barrel					144.0'			122.0 - 126.8': Siltstone, sandy, shaly 125.0 - 126.0'; grades to sandstone 123.5 - 124.1', fine, silty; moderately cemented, friable; dark gray to gray.
		87	60						50			
	150											
			XX	Dropped 3' core.					152.2'			
		100	10						154.1'			
			XX	Blocked								126.8 - 134.4': Shale, clayey, silty, massive to fissile; compact; grades to silty shale 130.2 - 132.2'; carbon flakes 130.2 - 134.4'; dark gray to black; cuts easily with light knife pressure 130.2 - 132.2'.
	160	100	33						160.6			
			XXX	Recovered core left in hole on previous run.								
		100	15						70			134.4 - 144.0': Sandstone, fine, silty, limy 141.4 - 144.0', faintly to well laminated, moderately cemented, friable; can be scratched easily with moderate knife pressure; tan. Grades to sandy siltstone 143.0 - 144.0'.
	170											
		100	15						80			144.0 - 152.2': Shale, silty, clayey, slightly limy; compact, irregular thin beds to fissile; moderately hard 144.3 - 145.5' and 152.0 - 152.2'; jointed and slickensided; gray to dark gray; can be cut with knife easily 145.5 - 150'.
	180											
		99	28						90			
	190								191.3'			152.2 - 154.1': Sandstone, fine, silty; gray; moderately hard, can be scratched with moderate knife pressure.
		100	30						198.2'			

EXPLANATION

CORE LOSS

CORE RECOVERY

Type of hole . . . . . D = Diamond, H = Haystellite, S = Shot, C = Churn
Hole sealed . . . . . P = Packer, Cm = Cemented, Cs = Bottom of casing

Approx. size of hole (X-series) . .	Ex = 1-1/2",	Ax = 1-7/8",	Bx = 2-3/8",	Nx = 3"
Approx. size of core (X-series) . .	Ex = 7/8",	Ax = 1-1/8",	Bx = 1-5/8",	Nx = 2-1/8"
Outside dia. of casing (X-series) .	Ex = 1-13/16",	Ax = 2-1/4",	Bx = 2-7/8",	Nx = 3-1/2"
Inside dia. of casing (X-series) . .	Ex = 1-1/2",	Ax = 1-29/32",	Bx = 2-3/8",	Nx = 3"

* GPO 778-404

7-1937 (6-74)
Bureau of Reclamation

GEOLOGIC LOG OF DRILL HOLE

FEATURE: Kimbeto Study Site — PROJECT: EMRIA — STATE: New Mexico
HOLE NO.: DH-4K — LOCATION: San Juan County — GROUND ELEV.: 6,331.3' — DIP (ANGLE FROM HORIZ.): 90 degrees
COORDS. N. ____ E. ____
BEGUN: 5-3-77 — FINISHED: 5-10-77 — DEPTH OF OVERBURDEN: 33.5' — TOTAL DEPTH: 250.0' — BEARING: ____
DEPTH AND ELEV. OF WATER / LEVEL AND DATE MEASURED: See Notes — LOGGED BY: Luis Cabrera — LOG REVIEWED BY: J. L. Jackson

NOTES ON WATER LOSSES AND LEVELS, CASING, CEMENTING, CAVING, AND OTHER DRILLING CONDITIONS	TYPE AND SIZE OF HOLE	CORE RECOVERY (%)	PERCOLATION TESTS: DEPTH (FEET) FROM	PERCOLATION TESTS: DEPTH (FEET) TO	PERCOLATION TESTS: LOSS (G.P.M.)	PERCOLATION TESTS: PRESSURE (P.S.I.)	PERCOLATION TESTS: LENGTH OF TEST (MIN.)	ELEVATION (FEET)	DEPTH (FEET)	GRAPHIC LOG	SAMPLES FOR TESTING	CLASSIFICATION AND PHYSICAL CONDITION
5-16-77 Hole flushed and cleaned by jetting from 70 - 219'. Cemented at 219'. Cemented hole from 219 - 190' with 1.5 cubic feet by pumping through N rods. Set 1¼" PVC pipe to 190', lower 30' perforated. Pulled rods up to 180'. Left 1¼" PVC pipe suspended at 190'.	Nx		Coring Time (mins.)	XX	Left 1.8' core in hole				202.8'			154.1 - 160.8': Shale, silty, clayey, fissile, carbon specks along bedding, carbonaceous 160.4 - 160.8'; brown to black; grades to siltstone, fine sandy; laminated; moderately cemented; gray.
		98	21						206.7'			
	210		XX		Blocked, recovered core left in hole				10			
		100	8									160.8 - 191.3': Coal
		98	25						218.2'			191.3 - 194.8': Shale, clayey, silty, fissile, carbonaceous 191.3 - 192.5' and 194.3 - 194.8', with carbon flakes; compact; dark gray.
	220								20 221.1'			
									224.5'			194.8 - 198.2': Shale, silty clayey, poorly fissile, with carbon flakes and laminae; dark to gray green; absorbs water readily.
		94	37						255.9'			
	230		XX		Left 2.6' of core in hole				30			
									233.0'			198.2 - 202.8': Coal, shaly 198.2 - 198.4'; fractured; black.
		100	53									
			XX		Recovered lost core				239.5'			202.8 - 206.7': Siltstone, fine sandy, clayey; laminated; moderately hard, friable; gray.
	240								40			
		100	60						245.6'			206.7 - 218.2': Sandstone, fine, silty, massive to laminated, few carbon laminae, coal seam 218.1 - 218.2'; lightly to moderately cemented, friable; tan. Scratches easily with knife.
	Nx								250.0'			
	250								50			
												218.2 - 221.1': Shale, silty, clayey, fissile, some carbon laminae; compact; dark gray.
	60								60			
												221.1 - 224.5': Siltstone, fine sandy laminae, shaly and carbonaceous 224.2-224.5'; moderately hard, slightly friable.
	70								70			224.5 - 225.9': Coal.
												225.9 - 233.0': Shale, clayey, some carbon and silty laminae 225.9 - 230.0', fissile to poorly laminated; dark gray and dark green; compact.
	80								80			
												233.0 - 239.5': Siltstone, fine sandy from 235.5 - 238', grades to shaly siltstone with fine sandy laminae; moderately hard, crumbles with medium finger pressure; hard limy siltstone 238 - 238.7', calcite veinlets, few vugs (-3/8").
	90								90			

EXPLANATION

CORE LOSS
CORE RECOVERY

Type of hole . . . . . D = Diamond, H = Haystellite, S = Shot, C = Churn
Hole sealed . . . . . P = Packer, Cm = Cemented, Cs = Bottom of casing

Approx. size of hole (X-series)	Ex = 1-1/2",	Ax = 1-7/8",	Bx = 2-3/8",	Nx = 3"
Approx. size of core (X-series)	Ex = 7/8",	Ax = 1-1/8",	Bx = 1-5/8",	Nx = 2-1/8"
Outside dia. of casing (X-series)	Ex = 1-13/16",	Ax = 2-1/4",	Bx = 2-7/8",	Nx = 3-1/2"
Inside dia. of casing (X-series)	Ex = 1-1/2",	Ax = 1-29/32",	Bx = 2-3/8",	Nx = 3"

* GPO 778-404

7-1887 (6-74)
Bureau of Reclamation

GEOLOGIC LOG OF DRILL HOLE

SHEET. . . 4 . . OF. . 4 . . . .

FEATURE . Kimbeto Study Site . . . . . PROJECT. . EMRIA . . . . . STATE. New Mexico . . . . .

HOLE NO. . DH-4K . . LOCATION. . San Juan County. . . . . GROUND ELEV. . . 6,331.3' . . . . . DIP (ANGLE FROM HORIZ.) . . 90 degrees . . . . .
COORDS. N. . . . . E. . . . . TOTAL DEPTH

BEGUN . 5-3-77. . . . FINISHED. 5-10-77. . . . DEPTH OF OVERBURDEN . . 33.5' . . . . . 250' . . . BEARING. . . . . .

DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED. See Notes. . . . . LOGGED BY. Luis Cabrera . . . . . LOG REVIEWED BY. J. L. Jackson . . . . . .

NOTES ON WATER LOSSES AND LEVELS, CASING, CEMENTING, CAVING, AND OTHER DRILLING CONDITIONS	TYPE AND SIZE OF HOLE	CORE RECOVERY (%)	PERCOLATION TESTS: DEPTH (FEET) FROM (P, Cs, or Cm)	DEPTH (FEET) TO	LOSS (G.P.M.)	PRESSURE (P.S.I.)	LENGTH OF TEST (MIN.)	ELEVATION (FEET)	DEPTH (FEET)	GRAPHIC LOG	SAMPLES FOR TESTING	CLASSIFICATION AND PHYSICAL CONDITION
												239.5 - 245.6': Sandstone, fine to medium, silty, limy, laminated to cross-laminated; weakly cemented, friable; grades to siltstone 242.6 - 243.6, irregularly laminated; moderately cemented; tan and dark gray. 245.6 - 250.0': Shale, clayey, silty, fissile; grades to fine sandy siltstone 247.0 - 247.4' and 248.8 - 248.8'; moderately hard, laminated; jointed 45 degrees vertical; dark gray green.

EXPLANATION

CORE LOSS
CORE RECOVERY

Type of hole . . . . . D = Diamond, H = Haystellite, S = Shot, C = Churn
Hole sealed . . . . . P = Packer, Cm = Cemented, Cs = Bottom of casing
Approx. size of hole (X-series) . . Ex = 1-1/2", Ax = 1-7/8", Bx = 2-3/8", Nx = 3"
Approx. size of core (X-series) . . Ex = 7/8", Ax = 1-1/8", Bx = 1-5/8", Nx = 2-1/8"
Outside dia. of casing (X-series) . Ex = 1-13/16", Ax = 2-1/4", Bx = 2-7/8", Nx = 3-1/2"
Inside dia. of casing (X-series) . . Ex = 1-1/2", Ax = 1-29/32", Bx = 2-3/8", Nx = 3"

* GPO 778-404

7-1887 (6-74)
Bureau of Reclamation

GEOLOGIC LOG OF DRILL HOLE

SHEET 1 OF 5

FEATURE: Kimbeto Study Site — PROJECT: EMRIA — STATE: New Mexico
HOLE NO.: DH-5K — LOCATION: San Juan County — COORDS. N: ... E: ... — GROUND ELEV.: 6,331.5' — DIP (ANGLE FROM HORIZ.): 90 degrees
BEGUN: 9-27-77 — FINISHED: 10-14-77 — DEPTH OF OVERBURDEN: -- — TOTAL DEPTH: 474.0' — BEARING: ...
DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED: 121.0' 10-13-77 — LOGGED BY: W. Witt — LOG REVIEWED BY: J. Jackson

NOTES ON WATER LOSSES AND LEVELS, CASING, CEMENTING, CAVING, AND OTHER DRILLING CONDITIONS	TYPE AND SIZE OF HOLE	CORE RECOVERY (%)	PERCOLATION TESTS: DEPTH (FEET) FROM (P, Cs, or Cm)	PERCOLATION TESTS: DEPTH (FEET) TO	PERCOLATION TESTS: LOSS (G.P.M.)	PERCOLATION TESTS: PRESSURE (P.S.I.)	PERCOLATION TESTS: LENGTH OF TEST (MIN.)	ELEVATION (FEET)	DEPTH (FEET)	GRAPHIC LOG	SAMPLES FOR TESTING	CLASSIFICATION AND PHYSICAL CONDITION
Set Nx casing to 9.0', drilled casing to 10.0', and 45.0'. Used 4½" casing bit with 3-7/8" tricone pilot bit 0 - 9.0'; Nx wireline core barrel and diamond bit 9.0' to 474.0'. Dug mud pit in shale. Water Loss (%): 0 - 19.2', 0% 19.2 - 29.2', 20% 29.2 - 260.3', 0% 260.3 - 265.4', 25% 265.4 - 272.2', 50% 272.2 - 280.8', 75-100% 280.8 - 430.8', 100% 430.8 - 450.2', 90% 450.2 - 474.0', 100% Water Level Data Hole @ W.L. Date 91.1' 23.0' 9-30 111.3' 23.0' 10-01 172.2' 15.0' 10-03 234.2' 87.0' 10-04 290.2' 116.5' 10-05 339.4' 122.0' 10-07 382.0' 117.0' 10-08 406.7' 120.0' 10-10 430.8' 123.0' 10-11 469.1' 121.0' 10-12 474.0' 121.0' 10-13		0 56 86 72 89 99 96 98 100 97 96	Coring Time (mins.) 40 45 60 40 175	Crumbly, breaks in barrel 16.2' - 25.1'. Crumbled in seams 29.2'		25.1	-	9.0' 12.2' 23.0' 24.5' 28.7' 29.7' 31.5' 61.9' 63.5'			0.0 - 9.0': Weathered clay shale, tough. Logged from cuttings 9.0 - 12.2': Shale. Decomposed; clayey. 12.2 - 23.0': Shale. Very intensely weathered shale; tan to greenish gray; recovered as fragments. 23.0 - 24.5': Carbonaceous Shale. 24.5 - 28.7': Shale. Intensely weathered; rusty brown to gray. 28.7 - 29.7': Carbonaceous Shale. 29.7 - 31.5': Shale. Intensely weathered; rusty gray. 31.5 - 125.0': Sandstone. Shaly to silty; fine grained. 31.5 - 42.2': Moderately weathered, rusty brown to greenish gray. 42.2 - 125.0': Lightly weathered, greenish gray. 61.9 - 63.5': Carbonaceous Shale.

EXPLANATION

CORE LOSS
CORE RECOVERY

Type of hole . . . . . D = Diamond, H = Hoystellite, S = Shot, C = Churn
Hole sealed . . . . . P = Packer, Cm = Cemented, Cs = Bottom of casing
Approx. size of hole (X-series) . . Ex = 1-1/2", Ax = 1-7/8", Bx = 2-3/8", Nx = 3"
Approx. size of core (X-series) . . Ex = 7/8", Ax = 1-1/8", Bx = 1-5/8", Nx = 2-1/8"
Outside dia. of casing (X-series). Ex = 1-13/16", Ax = 2-1/4", Bx = 2-7/8", Nx = 3-1/2"
Inside dia. of casing (X-series) . . Ex = 1-1/2", Ax = 1-29/32", Bx = 2-3/8", Nx = 3"

* GPO 778-404

7-1887 (8-74)
Bureau of Reclamation

GEOLOGIC LOG OF DRILL HOLE

FEATURE: Kimbetp Study Site | PROJECT: EMRIA | STATE: New Mexico

HOLE NO.: DH-5K | LOCATION: San Juan County | GROUND ELEV.: 6,331.5' | DIP (ANGLE FROM HORIZ.): 90 degrees

COORDS. N: E: | BEGUN: 9-27-77 | FINISHED: 10-14-77 | DEPTH OF OVERBURDEN: -- | TOTAL DEPTH: 474.0' | BEARING:

DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED: 121.0' 10-13-77 | LOGGED BY: W. Witt | LOG REVIEWED BY: J. Jackson

NOTES ON WATER LOSSES AND LEVELS, CASING, CEMENTING, CAVING, AND OTHER DRILLING CONDITIONS	TYPE AND SIZE OF HOLE	CORE RECOVERY (%)	PERCOLATION TESTS: DEPTH (FEET) FROM	TO	LOSS (G.P.M.)	PRESSURE (P.S.I.)	LENGTH OF TEST (MIN.)	ELEVATION (FEET)	DEPTH (FEET)	GRAPHIC LOG	SAMPLES FOR TESTING	CLASSIFICATION AND PHYSICAL CONDITION
Hole geophysically logged 10-12-77 by G. S. Hole completion: Set 474' of 1½" PVC: perforated 354' to 474'. Isolated perforations with rubber sleeve and cement plug bottomed at 353'.	110 120 130 140 150 160 170 180 190	91 96 100 75 99 100 94	Coring Time (mins.) 75 55 75 80 95 40						10 20 125.0' 30 40 141.0' 142.5' 50 150.4' 60 167.0' 70 80 188.0' 90			125.0 - 141.0': Siltstone. Lightly weathered; clayey to sandy; greenish gray. 141.0 - 142.5': Carbonaceous Shale. 142.5 - 150.4': Siltstone. Lightly weathered; dark greenish gray. 150.4 - 167.0': Sandstone. Fresh; fine grained; silty; weakly cemented. 167.0 - 188.0': Shale. Fresh; clayey to silty; compact; few joints and slickensides. 188.0 - 218.8': Sandstone. Fresh; fine grained; silty. 210.1 - 218.8': Contains silty shale seams.

EXPLANATION

CORE LOSS

CORE RECOVERY

Type of hole	D = Diamond, H = Hoystellite, S = Shot, C = Churn			
Hole sealed	P = Packer, Cm = Cemented, Cs = Bottom of casing			
Approx. size of hole (X-series)	Ex = 1-1/2",	Ax = 1-7/8",	Bx = 2-3/8",	Nx = 3"
Approx. size of core (X-series)	Ex = 7/8",	Ax = 1-1/8",	Bx = 1-5/8",	Nx = 2-1/8"
Outside dia. of casing (X-series)	Ex = 1-13/16",	Ax = 2-1/4",	Bx = 2-7/8",	Nx = 3-1/2"
Inside dia. of casing (X-series)	Ex = 1-1/2",	Ax = 1-29/32",	Bx = 2-3/8",	Nx = 3"

* GPO 778-404

7-1337 (6-74)
Bureau of Reclamation

GEOLOGIC LOG OF DRILL HOLE

FEATURE: Kimbeto Study Site — PROJECT: EMRIA — STATE: New Mexico
HOLE NO.: DH-5K — LOCATION: San Juan County — GROUND ELEV.: 6,331.5' — DIP (ANGLE FROM HORIZ.): 90 degrees
BEGUN: 9-27-77 — FINISHED: 10-14-77 — DEPTH OF OVERBURDEN: -- — TOTAL DEPTH: 474.0' — BEARING:
DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED: 121.0' 10-13-77 — LOGGED BY: W. Witt — LOG REVIEWED BY: J. Jackson

NOTES ON WATER LOSSES AND LEVELS, CASING, CEMENTING, CAVING, AND OTHER DRILLING CONDITIONS	TYPE AND SIZE OF HOLE	CORE RECOVERY (%)	PERCOLATION TESTS: DEPTH (FEET)	TO	LOSS (G.P.M.)	PRESSURE (P.S.I.)	LENGTH OF TEST (MIN.)	ELEVATION (FEET)	DEPTH (FEET)	GRAPHIC LOG	SAMPLES FOR TESTING	CLASSIFICATION AND PHYSICAL CONDITION
			Coring Time (mins.)									
		93							10			
	210	95	75									
									218.8			218.8 - 234.0': Shale. Fresh; compact; clayey to silty; slickensided joints; few carbonaceous streaks. 229.6' - 232.0': Grades to a siltstone.
	220	86							20			
	230		60						30			
									234.0			234.0 - 256.5': Shale. Fresh; clayey to silty; slickensided joints. 240.0' - 243.0' and 244.0' - 248.0': slightly carbonaceous.
	Nx 240	100	60						40			
	250								50			
			45						256.5			256.5 - 260.9': Siltstone. Fresh; sandy to clayey; limy; moderately hard.
	260	100	25		Core broken by drill action 260.3' - 265.4'.				260.9			260.9 - 301.6': Coal. 290.7' - 291.6': Coal with clayey shale. 294.0' - 296.3': Coal with clayey shale.
	270		60						70			
		99										
	280		30						80			
	290								90			
		100	90									

EXPLANATION

CORE LOSS
CORE RECOVERY

Type of hole . . . . . D = Diamond, H = Haystellite, S = Shot, C = Churn
Hole sealed . . . . . P = Packer, Cm = Cemented, Cs = Bottom of casing
Approx. size of hole (X-series) . . Ex = 1-1/2", Ax = 1-7/8", Bx = 2-3/8", Nx = 3"
Approx. size of core (X-series) . . Ex = 7/8", Ax = 1-1/8", Bx = 1-5/8", Nx = 2-1/8"
Outside dia. of casing (X-series). Ex = 1-13/16", Ax = 2-1/4", Bx = 2-7/8", Nx = 3-1/2"
Inside dia. of casing (X-series). . Ex = 1-1/2", Ax = 1-29/32", Bx = 2-3/8", Nx = 3"

* GPO 778-404

7-1987 (6-74)
Bureau of Reclamation

GEOLOGIC LOG OF DRILL HOLE

FEATURE Kimbeto Study Site PROJECT EMRIA STATE New Mexico

HOLE NO. DH-5K LOCATION San Juan County COORDS. N. E. GROUND ELEV. 6,331.5' DIP (ANGLE FROM HORIZ.) 90 degrees

BEGUN 7-8-77 FINISHED 7-22-77 DEPTH OF OVERBURDEN -- TOTAL DEPTH 373.0' BEARING

DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED See Notes LOGGED BY W. Witt LOG REVIEWED BY J. Jackson

NOTES ON WATER LOSSES AND LEVELS, CASING, CEMENTING, CAVING, AND OTHER DRILLING CONDITIONS	TYPE AND SIZE OF HOLE	CORE RECOVERY (%)	PERCOLATION TESTS: DEPTH (FEET) FROM	PERCOLATION TESTS: DEPTH (FEET) TO	PERCOLATION TESTS: LOSS (G.P.M.)	PERCOLATION TESTS: PRESSURE (P.S.I.)	PERCOLATION TESTS: LENGTH OF TEST (MIN.)	ELEVATION (FEET)	DEPTH (FEET)	GRAPHIC LOG	SAMPLES FOR TESTING	CLASSIFICATION AND PHYSICAL CONDITION
		88	Coring Time (Mins.)						301.6'			301.6' - 307.7': Shale. Fresh; compact; clayey to silty; moderately hard. 303.2' - 305.5': Bentonitic.
									307.7'			
									308.6'			307.7' - 308.6': Coal.
									310.8'			
		90		30					312.4'			308.6' - 310.8': Shale. Fresh; clayey to silty; compact; low angle joints slickensided.
												310.8' - 312.4': Coal.
									322.2'			312.4' - 322.2': Shale. Fresh; compact; clayey to silty; irregular laminae; numerous slickensides.
		100		75					331.0'			322.2' - 331.0': Shale. Fresh; silty to clayey shale seams. 325.5' - 330.5': Grades to a siltstone.
									336.4'			331.0' - 336.4': Sandstone. Fresh; weakly cemented; fine to medium grained; slightly silty; friable.
									341.4'			336.4' - 341.4': Coal.
				60	Core broke by drill action.				343.3'			341.4' - 343.3': Shale. Fresh; clayey to silty; easily gouged with a knife.
		97							345.1'			343.3' - 345.1': Coal.
									348.3'			345.1' - 348.3': Shale. Fresh; clayey to silty; with carbonaceous and coal seams; scratches easily; crumbly.
									348.7'			348.3' - 348.7': Carbonaceous Shale. Contains small coal seams.
				290					351.3'			348.7' - 351.3': Coal.
		82							351.9'			351.3' - 351.9': Carbonaceous Shale.
									352.8'			351.9' - 352.8': Shale. Clayey to silty; slickensided joints.
									355.0'			352.8' - 355.0': Siltstone. Contains many silty shale laminae; slightly cemented.
				40								355.0' - 391.6': Sandstone. Fresh; very fine grained; silty.
		100		85					391.6'			391.6' - 401.8': Sandstone. Fresh; very fine grained; silty; slightly clayey; contains about 45% silty shale; clayey 0.1' to 1' interbeds as seams and laminae; moderately hard.

EXPLANATION

CORE LOSS

CORE RECOVERY

Type of hole . . . . . D = Diamond, H = Haystellite, S = Shot, C = Churn
Hole sealed . . . . . P = Packer, Cm = Cemented, Cs = Bottom of casing
Approx. size of hole (X-series) . . Ex = 1-1/2", Ax = 1-7/8", Bx = 2-3/8", Nx = 3"
Approx. size of core (X-series) . . Ex = 7/8", Ax = 1-1/8", Bx = 1-5/8", Nx = 2-1/8"
Outside dia. of casing (X-series). Ex = 1-13/16", Ax = 2-1/4", Bx = 2-7/8", Nx = 3-1/2"
Inside dia. of casing (X-series). . Ex = 1-1/2", Ax = 1-29/32", Bx = 2-3/8", Nx = 3"

* GPO 778-404

7-1337 (6-74)
Bureau of Reclamation

GEOLOGIC LOG OF DRILL HOLE

SHEET. . 5 . . . OF . 5 . . . . .

FEATURE . Kimbeto Study Site . . . . . PROJECT . . . EMRIA . . . . . STATE . New Mexico . . . . .

HOLE NO. DH-5K . . . . . LOCATION . . . San Juan County . . . . . GROUND ELEV. . . 6,331.5' . . . . . DIP (ANGLE FROM HORIZ.) . . 90 degrees . . . . .

COORDS. N. . . . . E. . . . . TOTAL DEPTH. 474.0' . . . BEARING. . . . . .

BEGUN . . 9-27-77 . FINISHED. 10-14-77 . . . DEPTH OF OVERBURDEN . -- . . . . . .

DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED . . 121.0' . . 10-13-77 . . . . . LOGGED BY . . . W. Witt . . . . . LOG REVIEWED BY . . J. Jackson . . . . . .

NOTES ON WATER LOSSES AND LEVELS, CASING, CEMENTING, CAVING, AND OTHER DRILLING CONDITIONS	TYPE AND SIZE OF HOLE	CORE RECOVERY (%)	PERCOLATION TESTS: DEPTH (FEET) FROM	PERCOLATION TESTS: DEPTH (FEET) TO	PERCOLATION TESTS: LOSS (G.P.M.)	PERCOLATION TESTS: PRESSURE (P.S.I.)	PERCOLATION TESTS: LENGTH OF TEST (MIN.)	ELEVATION (FEET)	DEPTH (FEET)	GRAPHIC LOG	SAMPLES FOR TESTING	CLASSIFICATION AND PHYSICAL CONDITION
			Coring Time (Mins.)						401.8'			401.8 - 409.1': Shale. Fresh; well compacted; clayey to silty; mostly low angle joints with a few 30 - 40 degrees.
			0	90					409.1'			409.1 - 412.3': Sandstone. Fresh; compact; very fine grained; silty to slightly clayay; lightly cemented. Contains about 35% clayey shale in seams 1" to 0.5'.
	410		90	180					412.3'			412.3 - 418.0': Shale. Fresh; compact; clayey to silty; moderately hard with about 50% sandy siltstone.
			0	90					418.0'			418.0 - 430.8': Siltstone. Fresh; sandy to slightly clayey; limy; moderately cemented with about 20% clayey shale seams to 1½" maximum; compact.
	420	100	90	150					430.8'			430.8 - 438.4': Siltstone. Fresh; compact to moderately hard; sandy to slightly clayey.
			0	60					438.4'			438.4 - 439.0': Shale. Fresh; silty to clayey; contains many laminae and seams of moderately hard siltstone.
	430		60	150					439.0'			439.0 - 450.3': Sandstone. Fresh; fine grained to silty; limy; hard to moderately cemented; clayey to silty seams to 0.1'.
			0	95					450.3'			450.3 - 464.0': Shale. Fresh; clayey to silty with siltstone and sandstone seams and laminae.
	440		95	190					464.0'			464.0 - 469.1': Siltstone and Sandstone Interbedded.
	Nx		0	95					469.1'			469.1 - 474.0': Shale. Fresh; compact; clayey to silty; moderately hard.
		98	95	190					474.0'			
	450		190	285								
			0	45								
	460		45	90								
			90	180								
	470	80	180	270								
			270	360								
	480											
	490											

EXPLANATION

CORE LOSS

CORE RECOVERY

Type of hole . . . . . D = Diamond, H = Haystellite, S = Shot, C = Churn
Hole sealed . . . . . P = Packer, Cm = Cemented, Cs = Bottom of casing
Approx. size of hole (X-series) . . Ex = 1-1/2", Ax = 1-7/8", Bx = 2-3/8", Nx = 3"
Approx. size of core (X-series) . . Ex = 7/8", Ax = 1-1/8", Bx = 1-5/8", Nx = 2-1/8"
Outside dia. of casing (X-series). Ex = 1-13/16", Ax = 2-1/4", Bx = 2-7/8", Nx = 3-1/2"
Inside dia. of casing (X-series). . Ex = 1-1/2", Ax = 1-29/32", Bx = 2-3/8", Nx = 3"

* GPO 778-404

7-1937 (6-74)
Bureau of Reclamation

GEOLOGIC LOG OF DRILL HOLE

SHEET 1 OF 4

FEATURE: Kimbeto Study Site — PROJECT: EMRIA — STATE: New Mexico
HOLE NO.: DH-6K — LOCATION: San Juan County — GROUND ELEV.: 6,281.3' — DIP (ANGLE FROM HORIZ.): 90 degrees
COORDS. N: E: — TOTAL DEPTH: 373.0' — BEARING:
BEGUN: 7-8-77 — FINISHED: 7-22-77 — DEPTH OF OVERBURDEN: --
DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED: See Notes — LOGGED BY: W. Witt — LOG REVIEWED BY: J. Jackson

NOTES ON WATER LOSSES AND LEVELS, CASING, CEMENTING, CAVING, AND OTHER DRILLING CONDITIONS	TYPE AND SIZE OF HOLE	CORE RECOVERY (%)	PERCOLATION TESTS: DEPTH (FEET) FROM	PERCOLATION TESTS: DEPTH (FEET) TO	PERCOLATION TESTS: LOSS (G.P.M.)	PERCOLATION TESTS: PRESSURE (P.S.I.)	PERCOLATION TESTS: LENGTH OF TEST (MIN.)	ELEVATION (FEET)	DEPTH (FEET)	GRAPHIC LOG	SAMPLES FOR TESTING	CLASSIFICATION AND PHYSICAL CONDITION
Used 3-7/8" tricone rockbit 0 - 3'.	3-7/8"		Coring Time (Mins.)						1.5'			0' - 1.5': No recovery.
Used Nx-C3 wireline core barrel with diamond bit 3' - 373'.		75	25									1.5' - 37.0': Silty Shale; Moderately weathered; tan to medium gray; very intensely fractured.
	10	74							10			1.8' - 3.0': No recovery.
Set Nx casing to 10'; to 39'; to 93'; to 98'.												14.0' - 15.0': Carbonaceous Shale. Recovered as fragments.
			50									23.6' - 24.6': Carbonaceous Shale. Recovered as fragments.
Hole caving from approximately 57' to 159'.	20	56							20			26.0' - 27.2': Carbonaceous Shale. Recovered as fragments to 0.3' core lengths.
Water Losses (%):												
0 - 223.9'; 0%	30	90	45						30			
223.9 - 245.2'; 10%												
245.2 - 373.0'; 0%									37.0'			37.0' - 39.7': Sandy Siltstone. Lightly to moderately weathered; light to medium gray; intensely fractured.
Water Levels:	40	99	20						39.7' 40			
Hole @ W.L.	Nx								47.0'			39.7' - 47.0': Sandstone. Lightly to moderately weathered; light gray; intensely to moderately fractured.
164.4' 25.7' 7/15/77												
184.7' 22.0' 7/16/77												
245.2' 68.8' 7/18/77												
305.3' 67.5' 7/19/77	50		25						50			47.0' - 54.8': Silty sandstone. Lightly weathered; light gray; fine to medium grained; intensely to moderately fractured.
373.0' 58.5' 7/20/77		100							54.8'			
Hole geophysically logged 7/21/77 by G.S.	60		35						60			54.8' - 64.4': Sandstone. Fresh; light gray; medium grained; moderately fractured.
				Core broken by drill action 64.3' - 84.3'					64.4'			64.4' - 82.0': Sandy Siltstone. Fresh; greenish gray; intensely fractured.
Hole Completion: Set 1½" PVC pipe 0 - 355.7', perforated 205.7' - 305.7'. Cemented hole 310' - 360'. Set packer and placed cement plug bottomed at 204'.	70	94	60						70			82.0' - 84.8': Carbonaceous Siltstone. Greenish gray with 10-15% thin black carbonaceous laminae.
												84.8' - 95.0': Siltstone. Fresh; greenish gray; near horizontally bedded; intensely fractured.
	80	100	30						82.0'			85.5' - 85.9': Ash and Bentonitic Clay. Very light green; recovered in ¼" - 0.1' core lengths.
									84.8'			
	90		60						90			
									95.0'			95.0' - 114.0': Sandstone. Limy; light greenish gray; medium grained; massive.

EXPLANATION

CORE LOSS
CORE RECOVERY

Type of hole . . . . . D = Diamond, H = Haystellite, S = Shot, C = Churn
Hole sealed . . . . . P = Packer, Cm = Cemented, Cs = Bottom of casing
Approx. size of hole (X-series) . . Ex = 1-1/2", Ax = 1-7/8", Bx = 2-3/8", Nx = 3"
Approx. size of core (X-series) . . Ex = 7/8", Ax = 1-1/8", Bx = 1-5/8", Nx = 2 1 8"
Outside dia. of casing (X-series). Ex = 1-13/16", Ax = 2-1/4", Bx = 2-7 8", Nx = 3-1 2"
Inside dia. of casing (X-series). . Ex = 1-1/2", Ax = 1-29/32", Bx = 2-3 8", Nx = 3"

* GPO 778-404

7-1937 (6-74)
Bureau of Reclamation

GEOLOGIC LOG OF DRILL HOLE

SHEET 2 OF 4

FEATURE: Kimbeto Study Site — PROJECT: EMRIA — STATE: New Mexico
HOLE NO.: DH-6K — LOCATION: San Juan County — GROUND ELEV.: 6,281.3' — DIP (ANGLE FROM HORIZ.): 90 degrees
BEGUN: 7-8-77 — FINISHED: 7-22-77 — COORDS. N: ... E: ... — DEPTH OF OVERBURDEN: -- — TOTAL DEPTH: 373.0' — BEARING:
DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED: See Notes — LOGGED BY: W. Witt — LOG REVIEWED BY: J. Jackson

NOTES ON WATER LOSSES AND LEVELS, CASING, CEMENTING, CAVING, AND OTHER DRILLING CONDITIONS	TYPE AND SIZE OF HOLE	CORE RECOVERY (%)	PERCOLATION TESTS: DEPTH (FEET)	TO	LOSS (G.P.M.)	PRESSURE (P.S.I.)	LENGTH OF TEST (MIN.)	ELEVATION (FEET)	DEPTH (FEET)	GRAPHIC LOG	SAMPLES FOR TESTING	CLASSIFICATION AND PHYSICAL CONDITION
		96	Coring Time (0 Mins.)									114.0' - 117.0': Carbonaceous Sandstone. Medium gray with black streaks; fine sand; very intensely fractured.
		100	70						10			117.0' - 121.2': Sandy Siltstone. Fresh; medium gray; very intensely fractured.
		93							114.0'			121.2' - 125.6': Bentonitic Ash. Light green; slick; horizontally bedded.
									117.0'			125.6' - 126.2': Carbonaceous Siltstone. Dark gray to green; thinly laminated.
									20			
									121.2'			126.2' - 135.6': Siltstone. Contains 5% streaks of bentonitic clay; light green; very intensely fractured.
			40						125.6'			
									126.2'			
									30			
		100	45						135.6'			135.6' - 146.8': Sandstone. Fresh; light greenish gray; medium grained; massive; moderately to lightly fractured.
									40			
	NX		45						146.8'			146.8' - 153.0': Shale. Light to dark gray; very intensely fractured.
									50			
			Core broken by drill action 154.4' - 164.4'						153.0'			153.0' - 155.6': Sandstone. Medium gray; very intensely fractured.
									155.6'			155.6' - 157.4': Shale. Medium gray; very intensely fractured.
		100	45						156.5'			157.4' - 161.0': Shale. Medium gray; very intensely fractured.
									157.4'			161.0' - 163.0': Sandstone. Medium gray; very intensely fractured.
									60			163.0' - 163.8': Shale. Contains 5% thin carbonaceous streaks; medium gray; very intensely fractured.
									161.0'			163.8' - 171.0': Shale.
									163.0'			
									163.8'			
			70						170			
									171.0'			171.0' - 181.6': Shale. Contains 10% thin carbonaceous streaks.
									171.3'			171.3' - 172.0': Coal.
									172.0'			178.7' - 179.4': Coal.
		98							178.7'			
			60						179.4'			181.6' - 199.2': Shale.
									181.6'			
									90			199.2' - 204.3': Sandstone. Light greenish gray; massive; moderately to lightly fractured.
			60									
		100										
			60						199.2'			

EXPLANATION

CORE LOSS
CORE RECOVERY

Type of hole . . . . . D = Diamond, H = Haystellite, S = Shot, C = Churn
Hole sealed . . . . . P = Packer, Cm = Cemented, Cs = Bottom of casing

Approx. size of hole (X-series)	Ex = 1-1/2''	Ax = 1-7/8''	Bx = 2-3/8'', Nx = 3''
Approx. size of core (X-series)	Ex = 7/8''	Ax = 1-1/8''	Bx = 1-5/8'', Nx = 2-1/8''
Outside dia. of casing (X-series)	Ex = 1-13/16''	Ax = 2-1/4''	Bx = 2-7/8'', Nx = 3-1/2''
Inside dia. of casing (X-series)	Ex = 1-1/2''	Ax = 1-29/32''	Bx = 2-3/8'', Nx = 3''

* GPO 778-404

7-1337 (6-74)
Bureau of Reclamation

GEOLOGIC LOG OF DRILL HOLE

FEATURE: Kimbeto Study Site | PROJECT: EMRIA | STATE: New Mexico
HOLE NO.: DH-6K | LOCATION: San Juan County | COORDS. N. ... E. ... | GROUND ELEV.: 6,281.3' | DIP (ANGLE FROM HORIZ.): 90 degrees
BEGUN: 7-8-77 | FINISHED: 7-22-77 | DEPTH OF OVERBURDEN: -- | TOTAL DEPTH: 373.0' | BEARING:
DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED: See Notes | LOGGED BY: W. Witt | LOG REVIEWED BY: J. Jackson

NOTES ON WATER LOSSES AND LEVELS, CASING, CEMENTING, CAVING, AND OTHER DRILLING CONDITIONS	TYPE AND SIZE OF HOLE	CORE RECOVERY (%)	PERCOLATION TESTS: DEPTH (FEET)	TO	LOSS (G.P.M.)	PRESSURE (P.S.I.)	LENGTH OF TEST (MIN.)	ELEVATION (FEET)	DEPTH (FEET)	GRAPHIC LOG	SAMPLES FOR TESTING	CLASSIFICATION AND PHYSICAL CONDITION
			Coring Time (Mins.)						204.3			204.3' - 288.0': Shale. Contains 5 - 10% carbonaceous streaks; light green to dark gray; very intensely fractured 214.0' - 232.9': Coal. 245.6' - 246.2': Coal. 255.0' - 258.8': Coal. 271.1' - 284.0': Coal. 284.0' - 285.1': No recovery.
	210		60						214.0			
	220								220			
		95	45						232.9			
	230			Core blocked in barrel on run 232.9' - 235.2'.					230			
	240		60						240			
	NX			Core broken by drill action . 245.2' - 254.8'.					245.6 246.2			
	250		60						250			
									255.0			
									258.8			
	260		60						260			
		100										
			45						270			
	270								271.1			
	280								280			
			80									
									284.0			
									288.0			288.0' - 303.4': Sandstone. Light greenish gray; massive; intensely to moderately fractured.
	290	89							290			
			20									

EXPLANATION

CORE LOSS
CORE RECOVERY

Type of hole ..... D = Diamond, H = Haystellite, S = Shot, C = Churn
Hole sealed ..... P = Packer, Cm = Cemented, Cs = Bottom of casing
Approx. size of hole (X-series) .. Ex = 1-1/2", Ax = 1-7/8", Bx = 2-3/8", Nx = 3"
Approx. size of core (X-series) .. Ex = 7/8", Ax = 1-1/8", Bx = 1-5/8", Nx = 2-1/8"
Outside dia. of casing (X-series). Ex = 1-13/16", Ax = 2-1/4", Bx = 2-7/8", Nx = 3-1/2"
Inside dia. of casing (X-series).. Ex = 1-1/2", Ax = 1-29/32", Bx = 2-3/8", Nx = 3"

* GPO 778-404

7-1937 (6-74)
Bureau of Reclamation

GEOLOGIC LOG OF DRILL HOLE

SHEET 4 OF 4

FEATURE: Kimbeto Study Site | PROJECT: EMRIA | STATE: New Mexico

HOLE NO.: ~~DH-6K~~ | LOCATION: San Juan County | COORDS. N. ... E. ... | GROUND ELEV.: 6,281.3' | DIP (ANGLE FROM HORIZ.): 90 degrees

BEGUN: 7-8-77 | FINISHED: 7-22-77 | DEPTH OF OVERBURDEN: -- | TOTAL DEPTH: 373.0' | BEARING:

DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED: See Notes | LOGGED BY: W. Witt | LOG REVIEWED BY: J. Jackson

NOTES ON WATER LOSSES AND LEVELS, CASING, CEMENTING, CAVING, AND OTHER DRILLING CONDITIONS	TYPE AND SIZE OF HOLE	CORE RECOVERY (%)	PERCOLATION TESTS: DEPTH (FEET) FROM / TO	PERCOLATION TESTS: LOSS (G.P.M.)	PERCOLATION TESTS: PRESSURE (P.S.I.)	PERCOLATION TESTS: LENGTH OF TEST (MIN.)	ELEVATION (FEET)	DEPTH (FEET)	GRAPHIC LOG	SAMPLES FOR TESTING	CLASSIFICATION AND PHYSICAL CONDITION
		98	Coring Time (Mins.)					303.4' 303.9' 307.4'			303.4' - 303.9': Coal. 303.9' - 307.4': Shale. Contains 5% thin carbonaceous streaks; horizontally bedded; very intensely fractured.
	310	95	60					10 312.6' 313.2'			307.4' - 312.6': Sandstone. Light greenish gray; medium grained. Contains a trace of carbonaceous streaks.
	320		45					318.3' 20 322.1'			312.6' - 313.2': Coal.
		100						324.7' 325.2'			313.2' - 337.5': Shale. Contains 2-8% thin carbonaceous streaks; very intensely fractured. 318.3' - 322.1': Coal. 324.7' - 325.2': Coal.
	330		70					30			
	NX II 340		70					337.5' 40			337.5' - 373.0': Sandstone. Light greenish gray; horizontally bedded; trace of dark gray 1/32" - 1/4" shale scattered throughout.
		99									
	350		10					50			
	360	97	15					60			
	370	92	30					70 373.0'			
	380							80			
	390							90			

EXPLANATION

CORE LOSS

CORE RECOVERY

Type of hole . . . . . D = Diamond, H = Haystellite, S = Shot, C = Churn
Hole sealed . . . . . P = Packer, Cm = Cemented, Cs = Bottom of casing
Approx. size of hole (X-series) . . Ex = 1-1/2", Ax = 1-7/8", Bx = 2-3/8", Nx = 3"
Approx. size of core (X-series) . . Ex = 7/8", Ax = 1-1/8", Bx = 1-5/8", Nx = 2-1/8"
Outside dia. of casing (X-series). Ex = 1-13/16", Ax = 2-1/4", Bx = 2-7/8", Nx = 3-1/2"
Inside dia. of casing (X-series). . Ex = 1-1/2", Ax = 1-29/32", Bx = 2-3/8", Nx = 3"

* GPO 778-404

7-1937 (6-74)
Bureau of Reclamation

GEOLOGIC LOG OF DRILL HOLE

SHEET 1 OF 3

FEATURE: Kimbeto Study Site | PROJECT: EMRIA | STATE: New Mexico
HOLE NO.: DH-7K | LOCATION: San Juan County | GROUND ELEV.: 6,346.8' | DIP (ANGLE FROM HORIZ.): 90 degrees
COORDS. N: E:
BEGUN: 8-29-77 | FINISHED: 9-8-77 | DEPTH OF OVERBURDEN: -- | TOTAL DEPTH: 292.0' | BEARING:
DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED: See Notes | LOGGED BY: W. Witt | LOG REVIEWED BY: J. Jackson

NOTES ON WATER LOSSES AND LEVELS, CASING, CEMENTING, CAVING, AND OTHER DRILLING CONDITIONS

Used 3-7/8" tricone rock bit 0 - 28';

Used Nx casing with reaming shoe 28' - 30'.

Used Nx-C3 wireline core barrel 30' - 292'.

Set Nx casing to 30'; to 60'; to 66'.

Water Loss (%):

30.0 - 35.0'; 20%
35.0 - 52.2'; 80%
52.2 - 65.0'; 100%
65.0 - 70.5'; 10%
70.5 - 84.8'; 10%
84.8 - 132.6'; 0%
132.6 - 180.2'; 25%
180.2 - 182.3'; 5%
182.3 - 235.1'; 0%
235.1 - 254.9'; 10%
254.9 - 264.7'; 0%
264.7 - 292.0'; 10%

Water Levels

Hole @	W.L.	Date
65.1	Dry	8/31/77
94.8	45.0	9/1/77
141.7	45.0	9/2/77
180.2	65.0	9/5/77
235.1	94.0	9/6/77
264.7	91.7	9/7/77

TYPE AND SIZE OF HOLE	CORE RECOVERY (%)	PERCOLATION TESTS: DEPTH (FEET)	TO	LOSS (G.P.M.)	PRESSURE (P.S.I.)	LENGTH OF TEST (MIN.)	ELEVATION (FEET)	DEPTH (FEET)	GRAPHIC LOG	SAMPLES FOR TESTING	CLASSIFICATION AND PHYSICAL CONDITION
3-7/8"		Coring Time (Mins.)						0.0'			0.0' - 18.0': Silty sand, soft to firm. Logged from cuttings.
								10			
								18.0'			18.0' - 30.0': Silty sand with minor clay, firm, yellowish tan. Logged from cuttings.
								20			
								30.0'			30.0' - 40.2': Shale. Intensely weathered; light green to tan; intensely fractured.
	97	45						40.2'			40.2' - 44.8': Siltstone. Intensely weathered; light green to tan; moderately fractured.
								44.8'			44.8' - 55.9': Shale. Intensely weathered; light green to tan; very intensely fractured.
		25						50			
	90							55.9'			55.9' - 60.5': Sandstone. Moderately weathered; light greenish gray; fine grained; intensely to moderately fractured.
		45						60.5'			
Nx								60.8'			60.5' - 60.8': Mudstone. Red; $CaCO_3$ healed; hard. Recovered in one 0.3' core length.
	100	15						68.0'			60.8' - 68.0': Shale. Moderately weathered; greenish gray; horizontally bedded; intensely fractured.
		20						70			
	84							74.2'			68.0' - 74.2': Sandstone. Contains about 10% shaly laminae 1/32-1/2" thick; lightly weathered; moderately fractured.
		325						80			
	89							90			74.2' - 94.8': Shale. Lightly weathered; silty; greenish gray; horizontally bedded; very intensely fractured.
								94.8'			94.8' - 111.7': Sandstone. Fresh; light greenish gray; medium grained; bedding dips about 5 degrees; moderately fractured.
	96										

EXPLANATION

CORE LOSS
CORE RECOVERY

Type of hole . . . . . D = Diamond, H = Hoystellite, S = Shot, C = Churn
Hole sealed . . . . . P = Packer, Cm = Cemented, Cs = Bottom of casing
Approx. size of hole (X-series) . . Ex = 1-1/2", Ax = 1-7/8", Bx = 2-3/8", Nx = 3"
Approx. size of core (X-series) . . Ex = 7/8", Ax = 1-1/8", Bx = 1-5/8", Nx = 2-1/8"
Outside dia. of casing (X-series). Ex = 1-13/16", Ax = 2-1/4", Bx = 2-7/8", Nx = 3-1/2"
Inside dia. of casing (X-series). . Ex = 1-1/2", Ax = 1-29/32", Bx = 2-3/8", Nx = 3"

* GPO 778-404

7-1937 (6-74)
Bureau of Reclamation

GEOLOGIC LOG OF DRILL HOLE

FEATURE: Kimbeto Study Site | PROJECT: EMRIA | STATE: New Mexico

HOLE NO.: DH-7K | LOCATION: San Juan County | GROUND ELEV.: 6,346.8' | DIP (ANGLE FROM HORIZ.): 90 degrees

BEGUN: 8-29-77 | FINISHED: 9-8-77 | DEPTH OF OVERBURDEN: -- | TOTAL DEPTH: 292.0' | BEARING:

DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED: See Notes | LOGGED BY: W. Witt | LOG REVIEWED BY: J. Jackson

NOTES ON WATER LOSSES AND LEVELS, CASING, CEMENTING, CAVING, AND OTHER DRILLING CONDITIONS	TYPE AND SIZE OF HOLE	CORE RECOVERY (%)	PERCOLATION TESTS: DEPTH (FEET)	TO	LOSS (G.P.M.)	PRESSURE (P.S.I.)	LENGTH OF TEST (MIN.)	ELEVATION (FEET)	DEPTH (FEET)	GRAPHIC LOG	SAMPLES FOR TESTING	CLASSIFICATION AND PHYSICAL CONDITION
Hole geophysically logged 9/7/77 by G.S.			Coring Time (Mins.)									
Hole Completion: Backfilled hole with cement 292' - 182'. Set 1½" PVC to 182'. Perforated 142' - 182'. Placed rubber sleeve and cement plug bottomed at 140'.	110		25						10			
		89	45						111.7'			108.5 - 111.7': Sandstone Breccia. Contains about 20% silt clasts 1/16" - 1" diameter; light green; intensely fractured.
	120								119.8' 20			111.7' - 119.8': Siltstone. Medium green with 10% ¼" - 0.2' light greenish gray sandy streaks; very intensely fractured.
			30									119.8' - 129.2': Sandstone. Contains about 15% 1/16" - 1/4" silty streaks; cross bedded; intensely fractured.
		95	20						129.2' 30			129.2' - 141.0': Siltstone. Contains about 20% sandstone in streaks 1/4" - 1" wide; horizontally bedded; very intensely fractured.
	130											
		97	45									
	140								40			
									141.0'			141.0' - 142.7': Sandstone. Light greenish gray; fine grained; moderately jointed.
									142.7'			
	Nx		15									142.7' - 166.0': Coal.
	150								50			
		98		Core blocking in barrel 151.7' - 161.2'.								166.0' - 176.6': Siltstone. Contains about 30% ¼" - 0.2' sandstone streaks; green to light greenish gray; intensely to moderately fractured.
			12									169.4' - 176.6': Siltstone. Contains carbonaceous streaks; light green and black; very intensely fractured.
	160								60			170.7' - 175.8': Coal.
									166.0'			
			30									176.6' - 177.3': Sandstone. Contains about 10% siltstone streaks ¼" - ½" wide; light greenish gray. Recovered in one core length.
	170	95							170.7'			
			25						175.8' 176.6' 177.3' 178.4' 179.4' 180			177.3' - 178.4': Siltstone. Medium green; very intensely fractured.
	180											178.4' - 179.4': Sandstone. Light greenish gray; medium grained; horizontally bedded. Recovered in one core length.
		96	30									
	190								90			179.4' - 201.9': Sandstone and Siltstone Interbedded. Light greenish gray to medium green; interbeds 0.2' - 2.0' thick; fine to medium grained sandstone; intensely to moderately fractured.
		69	25									

EXPLANATION

CORE LOSS

CORE RECOVERY

Type of hole . . . . . D = Diamond, H = Haystellite, S = Shot, C = Churn
Hole sealed . . . . . P = Packer, Cm = Cemented, Cs = Bottom of casing
Approx. size of hole (X-series) . . Ex = 1-1/2", Ax = 1-7/8", Bx = 2-3/8", Nx = 3"
Approx. size of core (X-series) . . Ex = 7/8", Ax = 1-1/8", Bx = 1-5/8", Nx = 2-1/8"
Outside dia. of casing (X-series). Ex = 1-13/16", Ax = 2-1/4", Bx = 2-7/8", Nx = 3-1/2"
Inside dia. of casing (X-series) . . Ex = 1-1/2", Ax = 1-29/32", Bx = 2-3/8", Nx = 3"

* GPO 778-404

7-1937 (6-74)
Bureau of Reclamation

GEOLOGIC LOG OF DRILL HOLE

SHEET 3 OF 3

FEATURE Kimbeto Study Site PROJECT EMRIA STATE New Mexico

HOLE NO. DH-7K LOCATION San Juan County DIP (ANGLE FROM HORIZ.) 90 degrees

COORDS. N. E. GROUND ELEV. 6,146.8'

BEGUN 8-29-77 FINISHED 9-8-77 DEPTH OF OVERBURDEN -- TOTAL DEPTH 292.0' BEARING

DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED See Notes LOGGED BY W. Witt LOG REVIEWED BY J. Jackson

NOTES ON WATER LOSSES AND LEVELS, CASING, CEMENTING, CAVING, AND OTHER DRILLING CONDITIONS	TYPE AND SIZE OF HOLE	CORE RECOVERY (%)	PERCOLATION TESTS: DEPTH (FEET) FROM	PERCOLATION TESTS: DEPTH (FEET) TO	PERCOLATION TESTS: LOSS (G.P.M.)	PERCOLATION TESTS: PRESSURE (P.S.I.)	PERCOLATION TESTS: LENGTH OF TEST (MIN.)	ELEVATION (FEET)	DEPTH (FEET)	GRAPHIC LOG	SAMPLES FOR TESTING	CLASSIFICATION AND PHYSICAL CONDITION
			Coring Time (Mins.)						201.9'			201.9' - 226.5': Sandstone. Light greenish gray; massive to containing a trace of carbonaceous seams 1/32" - 1/4" thick; moderately weathered.
	210	100	25						10			
	220		20						20			
									226.5'			226.5' - 232.0': Siltstone. Sandy; medium green; very intensely fractured.
	230		30						30 232.0'			232.0' - 233.4': Sandstone. Light greenish gray; fine grained; massive. Recovered in one core length.
		91							233.4' 237.0'			233.4' - 237.0': Sandy Siltstone. Medium green to light greenish gray; intensely to moderately fractured.
	240		50						240.4' 241.0' 243.8'			237.0' - 271.3': Sandy Siltstone. Contains about 5% black carbonaceous streaks 1/16" - 3/4" thick; intensely to moderately fractured.
									246.0' 248.4' 50			240.3' - 241.0': Coal.
	250		120									243.8' - 246.0': Coal.
									256.0'			248.4' - 256.0': Coal.
	260	98							60			266.7' - 266.1': Silty Coal.
									264.7' 266.1'			
	270		30						70 271.3'			271.3' - 292.0': Sandstone. Light greenish gray; massive to near horizontally bedded; moderately fractured.
			20						80			
	280	100										
			10						90			
	290								292.0'			

EXPLANATION

CORE LOSS

CORE RECOVERY

Type of hole . . . . . D = Diamond, H = Haystellite, S = Shot, C = Churn
Hole sealed . . . . . P = Packer, Cm = Cemented, Cs = Bottom of casing
Approx. size of hole (X-series) . . Ex = 1-1/2", Ax = 1-7/8", Bx = 2-3/8", Nx = 3"
Approx. size of core (X-series) . . Ex = 7/8", Ax = 1-1/8", Bx = 1-5/8", Nx = 2 1/8"
Outside dia. of casing (X-series). Ex = 1-13/16", Ax = 2-1/4", Bx = 2-7/8", Nx = 3-1/2"
Inside dia. of casing (X-series). . Ex = 1-1/2", Ax = 1-29/32", Bx = 2-3/8", Nx = 3"

* GPO 778-404

7-1807 (6-74)
Bureau of Reclamation

GEOLOGIC LOG OF DRILL HOLE

SHEET 1 OF 3

FEATURE: Kimbeto Study Site | PROJECT: EMRIA | STATE: New Mexico

HOLE NO.: DH-8K | LOCATION: San Juan County | GROUND ELEV: 6,288.1' | DIP (ANGLE FROM HORIZ.): -90

COORDS. N: E:

BEGUN: 8-1-77 | FINISHED: 8-6-77 | DEPTH OF OVERBURDEN: --- | TOTAL DEPTH: 295.0 | BEARING:

DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED: See Notes | LOGGED BY: W. Witt | LOG REVIEWED BY: J. Jackson

NOTES ON WATER LOSSES AND LEVELS, CASING, CEMENTING, CAVING, AND OTHER DRILLING CONDITIONS	TYPE AND SIZE OF HOLE	CORE RECOVERY (%)	PERCOLATION TESTS: DEPTH (FEET)	TO	LOSS (G.P.M.)	PRESSURE (P.S.I.)	LENGTH OF TEST (MIN.)	ELEVATION (FEET)	DEPTH (FEET)	GRAPHIC LOG	SAMPLES FOR TESTING	CLASSIFICATION AND PHYSICAL CONDITION
Used hollow-continuous flight auger 0-84.0' and left in hole for casing. With hole at 200.2', advanced augers to 87.5'. With hole at 271.2', advanced augers to 92.5'. Used NX-C3 wireline core barrel w/diamond bit 84' - 295'. Hole logged geophysically 8-5-77 by G.S. Water Levels: Hole at WL Date 82.5 82.5 8-2-77 140.2 36.0 8-3-77 Hole Completion: Cemented hole 295'-180'. Set 1½" PVC pipe to 180', perforated 100'-180'. Placed rubber sleeve and cement plug bottomed at 80'.	8"		Coring Time (mins)						10 20 30 40 50 60 70 80			0.0'- 84.0': Silty to slightly clayey sand. Saturated at 40' ±. Logged from auger cuttings.
	NX	87	30						83.5' 84.7'			84.0' - 84.7': Siltstone. Intensely weathered; greenish gray to tan. Recovered as fragments to 0.2' core lengths.
												84.7' - 91.7': Sandstone. Fresh; light greenish gray; massive; horizontally bedded; intensely to moderately fractured.
		91	60						91.7' 93.7'			91.7' - 93.7': Siltstone. Sandy; green; intensely fractured.
												93.7' - 103.9': Sandstone. Carbonate cemented; light greenish gray; massive; intensely to moderately fractured.

EXPLANATION

CORE LOSS

CORE RECOVERY

Type of hole . . . . . D = Diamond, H = Haystellite, S = Shot, C = Churn
Hole sealed . . . . . P = Packer, Cm = Cemented, Cs = Bottom of casing
Approx. size of hole (X-series) . . Ex = 1-1/2", Ax = 1-7/8", Bx = 2-3/8", Nx = 3"
Approx. size of core (X-series) . . Ex = 7/8", Ax = 1-1/8", Bx = 1-5/8", Nx = 2-1/8"
Outside dia. of casing (X-series). Ex = 1-13/16", Ax = 2-1/4", Bx = 2-7/8", Nx = 3-1/2"
Inside dia. of casing (X-series) . . Ex = 1-1/2", Ax = 1-29/32", Bx = 2-3/8", Nx = 3"

* GPO 778-404

7-1487 (6-74)
Bureau of Reclamation

GEOLOGIC LOG OF DRILL HOLE

SHEET 2 OF 3

FEATURE: Kimbeto Study Site | PROJECT: EMRIA | STATE: New Mexico

HOLE NO.: DH-8K | LOCATION: San Juan County | GROUND ELEV.: 6,288.1' | DIP (ANGLE FROM HORIZ.): -90

COORDS. N. ..... E. .....

BEGUN: 8-1-77 | FINISHED: 8-6-77 | DEPTH OF OVERBURDEN: ---- | TOTAL DEPTH: 295.0 | BEARING:

DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED: See Notes | LOGGED BY: W. Witt | LOG REVIEWED BY: J. Jackson

NOTES ON WATER LOSSES AND LEVELS, CASING, CEMENTING, CAVING, AND OTHER DRILLING CONDITIONS	TYPE AND SIZE OF HOLE	CORE RECOVERY (%)	PERCOLATION TESTS: DEPTH (FEET)	TO	LOSS (G.P.M.)	PRESSURE (P.S.I.)	LENGTH OF TEST (MIN.)	ELEVATION (FEET)	DEPTH (FEET)	GRAPHIC LOG	SAMPLES FOR TESTING	CLASSIFICATION AND PHYSICAL CONDITION
			Coring Time (mins)						103.9'			103.9' - 128.0': Sandy Siltstone. Light to medium green; intensely fractured. 114.7' - 114.9': Mudstone. Red; hard; $CaCO_3$ healed. 125.4' - 125.8': Mudstone. Red; hard; $CaCO_3$ healed.
		100	45									
		97	45						128.0'			128.0' - 181.7': Siltstone. Contains sandy streaks, medium to light green; very intensely fractured. 161.5' - 162.2': Carbonaceous Shale 161.7' - 162.0': Coal. 178.3' - 179.4': Carbonaceous Shale
		90	45									
	NX	91	65									
		100	50									
			40						161.7' 162.0'			
			20									
		98	45						181.7'			181.7' - 191.4': Sandstone. Carbonate cemented; light greenish gray; fine to medium grained; massive; hard; moderate to lightly fractured. 191.4' - 241.2': Shale. Silty; very intensely fractured. 192.8' - 228.5': Coal. Contains a trace of thin siltstone seams. 228.5' - 229.4': Coal. 229.7' - 229.9': Coal. 231.3' - 231.5': Coal. 240.6' - 241.1': Coal.
		100	25						191.4' 192.8'			
		100	25									

EXPLANATION

CORE LOSS

CORE RECOVERY

Type of hole ..... D = Diamond, H = Hoystellite, S = Shot, C = Churn
Hole sealed ..... P = Packer, Cm = Cemented, Cs = Bottom of casing

Approx. size of hole (X-series)	Ex = 1-1/2'',	Ax = 1-7/8'',	Bx = 2-3/8'', Nx = 3''
Approx. size of core (X-series)	Ex = 7/8'',	Ax = 1-1/8'',	Bx = 1-5/8'', Nx = 2-1/8''
Outside dia. of casing (X-series)	Ex = 1-13/16'',	Ax = 2-1/4'',	Bx = 2-7/8'', Nx = 3-1/2''
Inside dia. of casing (X-series)	Ex = 1-1/2'',	Ax = 1-29/32'',	Bx = 2-3/8'', Nx = 3''

* GPO 778-404

7-1887 (6-74)
Bureau of Reclamation

GEOLOGIC LOG OF DRILL HOLE

SHEET 3 OF 3

FEATURE: Kimbeto Study Site | PROJECT: EMRIA | STATE: New Mexico
HOLE NO.: DH-8K | LOCATION: San Juan County | GROUND ELEV.: 6,288.1' | DIP (ANGLE FROM HORIZ.): -90
COORDS. N: E:
BEGUN: 8-1-77 | FINISHED: 8-6-77 | DEPTH OF OVERBURDEN: --- | TOTAL DEPTH: 295.0 | BEARING:
DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED: See Notes | LOGGED BY: W. Witt | LOG REVIEWED BY: J. Jackson

NOTES ON WATER LOSSES AND LEVELS, CASING, CEMENTING, CAVING, AND OTHER DRILLING CONDITIONS	TYPE AND SIZE OF HOLE	CORE RECOVERY (%)	PERCOLATION TESTS: DEPTH (FEET) FROM / TO	LOSS (G.P.M.)	PRESSURE (P.S.I.)	LENGTH OF TEST (HRS.)	ELEVATION (FEET)	DEPTH (FEET)	GRAPHIC LOG	SAMPLES FOR TESTING	CLASSIFICATION AND PHYSICAL CONDITION
			Coring Time (Mins)								
	210		14					10			
	220	100	9					20			
			35								
	230							30			
			50								
	240							40			
		100						241.2'			241.2' - 244.2': Siltstone. Sandy; light green; intensely fractured.
								244.2'			244.2' - 271.0': Sandstone. Light greenish gray; fine to medium grained; massive to streaked with a trace of carbonaceous shale; medium to lightly fractured.
	Nx		15								256.7' - 257.2': Sandstone and Carbonaceous Shale. Interbedded 1/32" - 1/2" thicknesses.
	250							50			260.8' - 261.4': Sandstone and Carbonaceous Shale. Interbedded 1/32" - 1/16" thicknesses.
			12								
	260	100						60			
			45								
	270							70			
								271.0'			271.0' - 277.7': Sandstone and Carbonaceous Shale. Interbedded 1/32" - 0.2', mostly 1/32" - 1/4" thicknesses.
		90	35								
								277.7'			277.7 - 286.8': Sandstone. Contains about 15% 1/4" - 0.2' carbonaceous shale seams.
	280							80			
		93	15					286.8'			286.8' - 287.3': Coal.
								287.3'			287.3' - 288.4': Carbonaceous Shale.
								288.4'			288.4' - 289.6': Coal. Shaly.
	290							289.6'			289.6' - 290.2': Shale. Silty; dark gray; very intensely fractured.
		100	40					290.2'			290.2' - 295.0': Sandy Siltstone. Light to medium gray; very intensely fractured.
								295.0'			

EXPLANATION

CORE LOSS
CORE RECOVERY

Type of hole . . . . . D = Diamond, H = Hoystellite, S = Shot, C = Churn
Hole sealed . . . . . P = Packer, Cm = Cemented, Cs = Bottom of casing
Approx. size of hole (X-series) . . Ex = 1-1/2", Ax = 1-7/8", Bx = 2-3/8", Nx = 3"
Approx. size of core (X-series) . . Ex = 7/8", Ax = 1-1/8", Bx = 1-5/8", Nx = 2-1/8"
Outside dia. of casing (X-series). Ex = 1-13/16", Ax = 2-1/4", Bx = 2-7/8", Nx = 3-1/2"
Inside dia. of casing (X-series). . Ex = 1-1/2", Ax = 1-29/32", Bx = 2-3/8", Nx = 3"

* GPO 778-404

7 1937 (6-74)
Bureau of Reclamation

GEOLOGIC LOG OF DRILL HOLE

SHEET 1 OF 4

FEATURE: Kimbeto Study Site | PROJECT: EMRIA | STATE: New Mexico

HOLE NO.: DH-9K | LOCATION: San Juan County | COORDS. N. ... E. ... | GROUND ELEV.: 6,331.2' | DIP (ANGLE FROM HORIZ.): 90 degrees

BEGUN: 8-17-77 | FINISHED: 8-27-77 | DEPTH OF OVERBURDEN: -- | TOTAL DEPTH: 335.1 | BEARING: ...

DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED: See Notes | LOGGED BY: W. Witt | LOG REVIEWED BY: J. Jackson

NOTES ON WATER LOSSES AND LEVELS, CASING, CEMENTING, CAVING, AND OTHER DRILLING CONDITIONS

Used 8" auger 0 - 12.5'. Used 3-7/8" tricone rockbit 12.5' - 69'. Used NX-C3 wireline core barrel with diamond bit 69.0' - 335.1'.

Set NW casing to 69'; to 109'.

Water Loss (%):

69.0' - 139.4': 0
139.4' - 165.2': 5
165.2' - 170.2': 75
170.2' - 335.1': 0

Water Levels:

Hole @	W.L.	Date
69.0	8.0	8/18
165.2	74.0	8/22
200.2	47.0	8/24
250.2	46.0	8/25
325.1	47.0	8/26

Hole Completion:

Cemented hole 138'-130' above packer. Set 1½" PVC to 130', perforated 80' - 130'. Placed rubber sleeve and cement plug bottomed at 70'.

TYPE AND SIZE OF HOLE	CORE RECOVERY (%)	PERCOLATION TESTS: DEPTH (FEET) FROM	TO	LOSS (G.P.M.)	PRESSURE (P.S.I.)	LENGTH OF TEST (MIN.)	ELEVATION (FEET)	DEPTH (FEET)	GRAPHIC LOG	SAMPLES FOR TESTING	CLASSIFICATION AND PHYSICAL CONDITION
8"								0.0'			0.0' - 66.4': Silty sand with traces of clay. Fragments (-¼") of coal. 45.0' - 66.4': Logged from cuttings.
3 7/8"								66.4'			66.4' - 69.0': Shale, weathered but firm. Logged from cuttings.
	0							69.0'			69.0' - 70.0': No recovery.
	100	25						70.0'			70.0' - 79.9': Silty Shale. Contains about 5% carbonaceous seams 1/16" - 1/8" wide; soft; moderately weathered. Recovered in 0.1' - 0.6' core lengths. 79.0' - 79.5': No recovery.
	86	15						79.9'			79.0' - 86.3': Carbonaceous Shale. 86.3' - 86.7': No recovery.
	100	20						86.3' 86.7' 87.3' 90 91.5' 91.8' 95.0' 96.1'			86.7' - 87.3': Siltstone. Greenish gray; intensely fractured. 87.3' - 91.5': Sandstone. Contains about 15% 1/16" - 1" Siltstone streaks; intensely to moderately fractured. 91.5' - 91.8': Coal. Shaly. 91.8' - 107.8': Shale. Silty to sandy; light green; intensely fractured.

EXPLANATION

CORE LOSS
CORE RECOVERY

Type of hole ..... D = Diamond, H = Hoystellite, S = Shot, C = Churn
Hole sealed ..... P = Packer, Cm = Cemented, Cs = Bottom of casing
Approx. size of hole (X-series) .. Ex = 1-1/2", Ax = 1-7/8", Bx = 2-3/8", Nx = 3"
Approx. size of core (X-series) .. Ex = 7/8", Ax = 1-1/8", Bx = 1-5/8", Nx = 2-1/8"
Outside dia. of casing (X-series). Ex = 1-13/16", Ax = 2-1/4", Bx = 2-7/8", Nx = 3-1/2"
Inside dia. of casing (X-series) .. Ex = 1-1/2", Ax = 1-29/32", Bx = 2-3/8", Nx = 3"

* GPO 778-404

7-1887 (6-74)
Bureau of Reclamation

GEOLOGIC LOG OF DRILL HOLE

FEATURE: Kimbeto Study Site | PROJECT: EMRIA | STATE: New Mexico
HOLE NO.: DH-9K | LOCATION: San Juan County | COORDS. N. ..... E. ..... | GROUND ELEV.: 6,331.2' | DIP (ANGLE FROM HORIZ.): 90 degrees
BEGUN: 8-17-77 | FINISHED: 8-27-77 | DEPTH OF OVERBURDEN: -- | TOTAL DEPTH: 335.1' | BEARING:
DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED: See Notes | LOGGED BY: W. Witt | LOG REVIEWED BY: J. Jackson

NOTES ON WATER LOSSES AND LEVELS, CASING, CEMENTING, CAVING, AND OTHER DRILLING CONDITIONS	TYPE AND SIZE OF HOLE	CORE RECOVERY (%)	PERCOLATION TESTS: DEPTH (FEET)	PERCOLATION TESTS: LOSS (G.P.M.)	PERCOLATION TESTS: PRESSURE (P.S.I.)	PERCOLATION TESTS: LENGTH OF TEST (MIN.)	ELEVATION (FEET)	DEPTH (FEET)	GRAPHIC LOG	SAMPLES FOR TESTING	CLASSIFICATION AND PHYSICAL CONDITION
		71	Coring Time (Mins.)								95.0' - 96.1': Carbonaceous Shale. 103.0' - 104.6': Sandy Shale. 104.6' - 105.1': Carbonaceous Shale.
								107.8			
	110	89						10			107.8' - 129.5': Sandstone. Light greenish gray; massive to light bedding which varies from 0 degrees to 15 degree dip. 122.8' - 123.2': Shale. Dark gray. 124.0' - 124.6': Shale. Dark gray.
	120	90	15					20			
								122.8			
								123.2			
								124.0			
								124.6			
			35					129.5			129.5' - 130.2': Shaly Coal.
	130	99						130.2			130.2' - 156.6': Siltstone. Clayey to sandy; light to medium green; very intensely fractured. 138.6' - 140.0': Coal. 147.2' - 148.5': Coal.
			30					138.6			
	140							140.0			
	NX	95	60					147.2			
								148.5			
	150							50			
		60	45					156.6			156.6' - 173.0': Sandstone. Light greenish gray; bedding dips 5-15 degrees; moderately to lightly fractured.
	160	86	30					60			
		100	15								
	170							70			
		60	10	Core blocked in barrel at 174.5'.				173.0			173.0' - 174.5': Coal.
								174.5			174.5' - 176.7': Bentonite Shale. 176.5' - 176.7': No recovery.
		73	45					176.7			176.7' - 189.4': Carbonaceous Shale. 179.2' - 180.9': Coal. 183.0' - 185.6': Coal. Shaly.
	180							179.2			
								180.9			
								183.0			
		74	40					185.6			
								189.4			189.4' - 191.6': Coal.
	190			Core blocked in barrel at 191.2'.				190			
								191.6			191.6' - 197.7': Clayey Shale. Medium green; very intensely fractured.
		99	85					197.7			197.7' - 201.9': Coal.
				Core blocked in barrel at 200.2'.							

EXPLANATION

CORE LOSS
CORE RECOVERY

Type of hole ..... D = Diamond, H = Haystellite, S = Shot, C = Churn
Hole sealed ..... P = Packer, Cm = Cemented, Cs = Bottom of casing
Approx. size of hole (X-series) .. Ex = 1-1/2", Ax = 1-7/8", Bx = 2-3/8", Nx = 3"
Approx. size of core (X-series) .. Ex = 7/8", Ax = 1-1/8", Bx = 1-5/8", Nx = 2-1/8"
Outside dia. of casing (X-series). Ex = 1-13/16", Ax = 2-1/4", Bx = 2-7/8", Nx = 3-1/2"
Inside dia. of casing (X-series) .. Ex = 1-1/2", Ax = 1-29/32", Bx = 2-3/8", Nx = 3"

* GPO 778-404

7 1937 (6-74)
Bureau of Reclamation

GEOLOGIC LOG OF DRILL HOLE

SHEET 1 OF 4

FEATURE: Kimbeto Study Site — PROJECT: EMRIA — STATE: New Mexico

HOLE NO.: DH-9K — LOCATION: San Juan County — GROUND ELEV.: 6,331.2' — DIP (ANGLE FROM HORIZ.): 90 degrees

COORDS. N: — E: — TOTAL DEPTH: 335.1 — BEARING:

BEGUN: 8-17-77 — FINISHED: 8-27-77 — DEPTH OF OVERBURDEN: --

DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED: See Notes — LOGGED BY: W. Witt — LOG REVIEWED BY: J. Jackson

NOTES ON WATER LOSSES AND LEVELS, CASING, CEMENTING, CAVING, AND OTHER DRILLING CONDITIONS

Used 8" auger 0 - 12.5'. Used 3-7/8" tricone rockbit 12.5' - 69'. Used NX-C3 wireline core barrel with diamond bit 69.0' - 335.1'.

Set NW casing to 69'; to 109'.

Water Loss (%):

69.0' - 139.4': 0
139.4' - 165.2': 5
165.2' - 170.2': 75
170.2' - 335.1': 0

Water Levels:

Hole @	W.L.	Date
69.0	8.0	8/18
165.2	74.0	8/22
200.2	47.0	8/24
250.2	46.0	8/25
325.1	47.0	8/26

Hole Completion:

Cemented hole 138'-130' above packer. Set 1½" PVC to 130', perforated 80' - 130'. Placed rubber sleeve and cement plug bottomed at 70'.

TYPE AND SIZE OF HOLE	CORE RECOVERY (%)	PERCOLATION TESTS: DEPTH (FEET) FROM	PERCOLATION TESTS: DEPTH (FEET) TO	PERCOLATION TESTS: LOSS (G.P.M.)	PERCOLATION TESTS: PRESSURE (P.S.I.)	PERCOLATION TESTS: LENGTH OF TEST (MIN.)	ELEVATION (FEET)	DEPTH (FEET)	GRAPHIC LOG	SAMPLES FOR TESTING	CLASSIFICATION AND PHYSICAL CONDITION
8"								0.0'			0.0' - 66.4': Silty sand with traces of clay. Fragments (-¼") of coal. 45.0' - 66.4': Logged from cuttings.
3 7/8"								66.4'			66.4' - 69.0': Shale, weathered but firm. Logged from cuttings.
								69.0'			69.0' - 70.0': No recovery.
	0							70.0'			70.0' - 79.9': Silty Shale. Contains about 5% carbonaceous seams 1/16" - 1/8" wide; soft; moderately weathered. Recovered in 0.1' - 0.6' core lengths. 79.0' - 79.5': No recovery.
	100	25						79.9'			79.0' - 86.3': Carbonaceous Shale. 86.3' - 86.7': No recovery.
	86	15						86.3'			86.7' - 87.3': Siltstone. Greenish gray; intensely fractured. 87.3' - 91.5': Sandstone. Contains about 15% 1/16" - 1" Siltstone streaks; intensely to moderately fractured. 91.5' - 91.8': Coal. Shaly. 91.8' - 107.8': Shale. Silty to sandy; light green; intensely fractured.
	100	20						91.5'			
								91.8'			
								95.0'			
								96.1'			

EXPLANATION

CORE LOSS
CORE RECOVERY

Type of hole . . . . . D = Diamond, H = Haystellite, S = Shot, C = Churn
Hole sealed . . . . . P = Packer, Cm = Cemented, Cs = Bottom of casing

Approx. size of hole (X-series)	Ex = 1-1/2",	Ax = 1-7/8",	Bx = 2-3/8",	Nx = 3"
Approx. size of core (X-series)	Ex = 7/8",	Ax = 1-1/8",	Bx = 1-5/8",	Nx = 2-1/8"
Outside dia. of casing (X-series)	Ex = 1-13/16",	Ax = 2-1/4",	Bx = 2-7/8",	Nx = 3-1/2"
Inside dia. of casing (X-series)	Ex = 1-1/2",	Ax = 1-29/32",	Bx = 2-3/8",	Nx = 3"

* GPO 778-404

7-1887 (6-74)
Bureau of Reclamation

GEOLOGIC LOG OF DRILL HOLE

FEATURE: Kimbeto Study Site | PROJECT: EMRIA | STATE: New Mexico
HOLE NO.: DH-9K | LOCATION: San Juan County | GROUND ELEV.: 6,331.2' | DIP (ANGLE FROM HORIZ.): 90 degrees
COORDS. N. ..... E. .....
BEGUN: 8-17-77 | FINISHED: 8-27-77 | DEPTH OF OVERBURDEN: -- | TOTAL DEPTH: 335.1' | BEARING:
DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED: See Notes | LOGGED BY: W. Witt | LOG REVIEWED BY: J. Jackson

NOTES ON WATER LOSSES AND LEVELS, CASING, CEMENTING, CAVING, AND OTHER DRILLING CONDITIONS	TYPE AND SIZE OF HOLE	CORE RECOVERY (%)	PERCOLATION TESTS: DEPTH (FEET) TO	LOSS (G.P.M.)	PRESSURE (P.S.I.)	LENGTH OF TEST (MIN.)	ELEVATION (FEET)	DEPTH (FEET)	GRAPHIC LOG	SAMPLES FOR TESTING	CLASSIFICATION AND PHYSICAL CONDITION
		73	Coring Time (Mins.)								95.0' - 96.1': Carbonaceous Shale. 103.0' - 104.6': Sandy Shale. 104.6' - 105.1': Carbonaceous Shale.
								107.8			
	110	89						10			107.8' - 129.5': Sandstone. Light greenish gray; massive to light bedding which varies from 0 degrees to 15 degree dip. 122.8' - 123.2': Shale. Dark gray. 124.0' - 124.6': Shale. Dark gray.
	120	90	15					20			
								122.8			
								123.2			
								124.0			
								124.6			
			35					129.5			129.5' - 130.2': Shaly Coal.
	130	99						130.2			130.2' - 156.6': Siltstone. Clayey to sandy; light to medium green; very intensely fractured. 138.6' - 140.0': Coal. 147.2' - 148.5': Coal.
			30								
								138.6			
	140							140.0			
	NX	95	60					147.2			
								148.5			
	150	60	45					50			
								156.6			156.6' - 173.0': Sandstone. Light greenish gray; bedding dips 5-15 degrees; moderately to lightly fractured.
	160	86	30					60			
		100	15								
	170	60	10	Core blocked in barrel at 174.5'.				70			
								173.0			173.0' - 174.5': Coal.
								174.5			174.5' - 176.7': Bentonite Shale. 176.5' - 176.7': No recovery.
		73	45					176.7			176.7' - 189.4': Carbonaceous Shale. 179.2' - 180.9': Coal. 183.0' - 185.6': Coal. Shaly.
	180							179.2			
								180.9			
								183.0			
		74	40					185.6			
								189.4			189.4' - 191.6': Coal.
	190			Core blocked in barrel at 191.2'.				190			
								191.6			191.6' - 197.7': Clayey Shale. Medium green; very intensely fractured.
		99	85								
								197.7			197.7' - 201.9': Coal.
				Core blocked in barrel at 200.2'.							

EXPLANATION

CORE LOSS
CORE RECOVERY

Type of hole ..... D = Diamond, H = Haystellite, S = Shot, C = Churn
Hole sealed ..... P = Packer, Cm = Cemented, Cs = Bottom of casing
Approx. size of hole (X-series) .. Ex = 1-1/2", Ax = 1-7/8", Bx = 2-3/8", Nx = 3"
Approx. size of core (X-series) .. Ex = 7/8", Ax = 1-1/8", Bx = 1-5/8", Nx = 2-1/8"
Outside dia. of casing (X-series). Ex = 1-13/16", Ax = 2-1/4", Bx = 2-7/8", Nx = 3-1/2"
Inside dia. of casing (X-series) .. Ex = 1-1/2", Ax = 1-29/32", Bx = 2-3/8", Nx = 3"

* GPO 778-404

7-1887 (6-74)
Bureau of Reclamation

GEOLOGIC LOG OF DRILL HOLE

FEATURE Kimbeto Study Site PROJECT EMRIA STATE New Mexico

HOLE NO. DH-9K LOCATION San Juan County GROUND ELEV. 6,331.2' DIP (ANGLE FROM HORIZ.) 90 degrees

COORDS. N. E.

BEGUN 8-17-77 FINISHED 8-27-77 DEPTH OF OVERBURDEN -- TOTAL DEPTH 335.1' BEARING

DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED See Notes LOGGED BY W. Witt LOG REVIEWED BY J. Jackson

NOTES ON WATER LOSSES AND LEVELS, CASING, CEMENTING, CAVING, AND OTHER DRILLING CONDITIONS	TYPE AND SIZE OF HOLE	CORE RECOVERY (%)	PERCOLATION TESTS: DEPTH (FEET)	TO	LOSS (G.P.M.)	PRESSURE (P.S.I.)	LENGTH OF TEST (MIN.)	ELEVATION (FEET)	DEPTH (FEET)	GRAPHIC LOG	SAMPLES FOR TESTING	CLASSIFICATION AND PHYSICAL CONDITION
			Coring Time (Mins.)						201.9'			201.9' - 206.0': Shale. Clayey to silty.
									206.0'			206.0' - 214.5': Sandstone and Siltstone. Interbedded; intensely to moderately fractured; light to medium green.
	210		5						10			
			25						214.5'			214.5' - 217.7': Carbonaceous Shale. Sandy; dark gray to black; thinly bedded.
									217.7'			
	220	91		Core blocked in barrel at 220.3'.					20			217.7' - 239.3': Sandstone. Light greenish gray; massive to lightly bedded; moderate to lightly fractured.
			45									
	230								30			
		97	40									
			15	Core blocked in barrel at 237.0'.					239.3'			
	240								40			239.3' - 244.1': Coal.
		100	40						244.1'			244.1' - 246.6': Carbonaceous Sandstone. Dark gray; fine grained; contains 5-10% carbonaceous plates and streaks.
									246.6'			
	250								50			
		97	15									
	260								60			
		100	10									
	270								70			
			15						273.1'			
		94										
	280		10						281.4'			
									283.4'			
									283.5'			
	290		15						90			
		100										
			25									

EXPLANATION

CORE LOSS

CORE RECOVERY

Type of hole . . . . . D = Diamond, H = Haystellite, S = Shot, C = Churn
Hole sealed . . . . . P = Packer, Cm = Cemented, Cs = Bottom of casing

Approx. size of hole (X-series)	Ex = 1-1/2''	Ax = 1-7/8''	Bx = 2-3/8''	Nx = 3''
Approx. size of core (X-series)	Ex = 7/8''	Ax = 1-1/8''	Bx = 1-5/8''	Nx = 2-1 8''
Outside dia. of casing (X-series)	Ex = 1-13/16''	Ax = 2-1/4''	Bx = 2-7 8''	Nx = 3-1 2''
Inside dia. of casing (X-series)	Ex = 1-1/2''	Ax = 1-29/32''	Bx = 2-3 8''	Nx = 3''

* GPO 778-404

7-1937 (6-74)
Bureau of Reclamation

GEOLOGIC LOG OF DRILL HOLE

SHEET 4 OF 4

FEATURE Kimbeto Study Site PROJECT EMRIA STATE New Mexico

HOLE NO. DH-9K LOCATION San Juan County

COORDS. N. E. GROUND ELEV. 6,331.2' DIP (ANGLE FROM HORIZ.) 90 degrees

BEGUN 8-17-77 FINISHED 8-27-77 DEPTH OF OVERBURDEN -- TOTAL DEPTH 335.1' BEARING

DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED See Notes LOGGED BY W. Witt LOG REVIEWED BY J. Jackson

NOTES ON WATER LOSSES AND LEVELS, CASING, CEMENTING, CAVING, AND OTHER DRILLING CONDITIONS	TYPE AND SIZE OF HOLE	CORE RECOVERY (%)	PERCOLATION TESTS: DEPTH (FEET) FROM / TO	LOSS (G.P.M.)	PRESSURE (P.S.I.)	LENGTH OF TEST (MIN.)	ELEVATION (FEET)	DEPTH (FEET)	GRAPHIC LOG	SAMPLES FOR TESTING	CLASSIFICATION AND PHYSICAL CONDITION
			Coring Time (Mins.)								
	310	76	15					10			
	320	100	20					20			
			10					325.9			
	330	100	45					30			
								335.1			246.6' - 335.1': Sandstone. Light greenish gray; massive to bedded; moderately fractured; fine to coarse grained. 273.1' - 281.4': Coal. 283.4' - 283.5': Coal. 325.9' - 335.1': Silty Sandstone. Contains about 30% siltstone interbeds 1/4" - 0.2'; intensely fractured along bedding which is near horizontal.
	340							40			
	350							50			
	360							60			
	370							70			
	380							80			
	390							90			

EXPLANATION

CORE LOSS

CORE RECOVERY

Type of hole . . . . . D = Diamond, H = Haystellite, S = Shot, C = Churn
Hole sealed . . . . . P = Packer, Cm = Cemented, Cs = Bottom of casing
Approx. size of hole (X-series) . . Ex = 1-1/2", Ax = 1-7/8", Bx = 2-3/8", Nx = 3"
Approx. size of core (X-series) . . Ex = 7/8", Ax = 1-1/8", Bx = 1-5/8", Nx = 2-1/8"
Outside dia. of casing (X-series). Ex = 1-13/16", Ax = 2-1/4", Bx = 2-7/8", Nx = 3-1/2"
Inside dia. of casing (X-series). . Ex = 1-1/2", Ax = 1-29/32", Bx = 2-3/8", Nx = 3"

* GPO 778-404

7-1837 (6-74)
Bureau of Reclamation

GEOLOGIC LOG OF DRILL HOLE

SHEET. 1 ... OF. 5 ....

FEATURE ... Kimbeto Study Site ..... PROJECT ... EMRIA ..... STATE .. New Mexico .....

HOLE NO. .. DH-10K .. LOCATION ... San Juan County ..... GROUND ELEV. .. 6,431.2' ..... DIP (ANGLE FROM HORIZ.) .. 90 degrees .....

COORDS. N. ..... E. .....

BEGUN .. 9-12-77 .. FINISHED .. 9-24-77 ... DEPTH OF OVERBURDEN ... -- ..... TOTAL DEPTH .. 500.0' ... BEARING .....

DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED ... See Notes ..... LOGGED BY .. W. Witt ..... LOG REVIEWED BY .. J. Jackson .....

NOTES ON WATER LOSSES AND LEVELS, CASING, CEMENTING, CAVING, AND OTHER DRILLING CONDITIONS

Used 3-7/8" tricone rock bit 0 - 15'; advanced hole 15'-19' by washing through Nx casing.

Set Nx casing to 19'; to 60'; to 70'.

Water Loss (%):

19.0 - 31.2'; 50%
31.2 - 40.2'; 75%
40.2 - 62.2'; 100%
62.2 - 142.2'; 0%
142.2 - 204.6'; 20%
204.6 - 301.7'; 0%
301.7 - 311.7'; 20%
311. - 321.7'; 10%
321.7 - 421.2'; 0%
421.2 - 469.1'; 20%
469.1 - 500.0'; 0%

Hole geophysically logged 9/24/77 by G. S.

Water Levels:

Hole @	W.L.	Date
55.2	Dry	9/13/77
94.7	43.3	9/14/77
137.0	5.0	9/15/77
204.6	25.0	9/16/77
242.0	120.0	9/17/77
301.7	154.0	9/19/77
374.6	135.0	9/20/77
421.2	105.0	9/21/77
449.1	95.0	9/22/77
469.1	120.0	9/23/77
500.0	125.0	9/24/77

TYPE AND SIZE OF HOLE	CORE RECOVERY (%)	PERCOLATION TESTS: DEPTH (FEET) FROM	TO	LOSS (G.P.M.)	PRESSURE (P.S.I.)	LENGTH OF TEST (MIN.)	ELEVATION (FEET)	DEPTH (FEET)	GRAPHIC LOG	SAMPLES FOR TESTING	CLASSIFICATION AND PHYSICAL CONDITION
3-7/8		Coring Time (Mins.)						0.0'			0.0' - 8.0': Silty sand, trace clay. Logged from cuttings.
								8.0'			8.0' - 15.0': Sand, fine to medium grained, slightly silty. Logged from cuttings.
								15.0'			15.0' - 19.0': Shale, weathered, soft. Logged from cuttings.
								19.0'			19.0' - 67.8': Shale. Intensely weathered; rusty yellow, tan, and gray.
	84	20									62.6' - 63.8': Carbonaceous Shale. Dark gray.
	100		45								
	89										
	94		40								
Nx											
	93		55								
	94										
								67.8'			67.8' - 79.8': Sandstone. Moderately to lightly weathered; light gray with rust along joint surfaces.
	100		45								72.1' - 76.0': Siltstone. Sandy; lightly weathered; gray.
	93							79.8'			79.8' - 89.0': Shale. Lightly weathered; gray.
			40					89.0'			89.0' - 102.5': Sandstone. Fresh; light greenish gray. Contains less than 10% thin shaly laminations.
	100										
	96	75									

EXPLANATION

CORE LOSS
CORE RECOVERY

Type of hole ..... D = Diamond, H = Haystellite, S = Shot, C = Churn
Hole sealed ..... P = Packer, Cm = Cemented, Cs = Bottom of casing
Approx. size of hole (X-series) .. Ex = 1-1/2", Ax = 1-7/8", Bx = 2-3/8", Nx = 3"
Approx. size of core (X-series) .. Ex = 7/8", Ax = 1-1/8", Bx = 1-5/8", Nx = 2-1/8"
Outside dia. of casing (X-series). Ex = 1-13/16", Ax = 2-1/4", Bx = 2-7/8", Nx = 3-1/2"
Inside dia. of casing (X-series) .. Ex = 1-1/2", Ax = 1-29/32", Bx = 2-3/8", Nx = 3"

* GPO 778-404

7-1937 (6-74)
Bureau of Reclamation

GEOLOGIC LOG OF DRILL HOLE

FEATURE . . Kimbeto Study Site . . . . . PROJECT . . . EMRIA . . . . . STATE . . New Mexico . . . . . .

HOLE NO. . DH-10K . . LOCATION . . San Juan County . . . . . GROUND ELEV. . . 6,431.2' . . . . . DIP (ANGLE FROM HORIZ.) . . . 90 degrees . . . .

BEGUN . . 9-12-77 . . FINISHED. . . 9-24-77 . . DEPTH OF OVERBURDEN . . . . . TOTAL DEPTH . . . . . BEARING . . . . . .

DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED . See Notes . . . . . LOGGED BY . . W. Witt . . . . . LOG REVIEWED BY . . . J. Jackson . . . . . .

NOTES ON WATER LOSSES AND LEVELS, CASING, CEMENTING, CAVING, AND OTHER DRILLING CONDITIONS	TYPE AND SIZE OF HOLE	CORE RECOVERY (%)	PERCOLATION TESTS: DEPTH (FEET) FROM	PERCOLATION TESTS: DEPTH (FEET) TO	PERCOLATION TESTS: LOSS (G.P.M.)	PERCOLATION TESTS: PRESSURE (P.S.I.)	PERCOLATION TESTS: LENGTH OF TEST (MIN.)	ELEVATION (FEET)	DEPTH (FEET)	GRAPHIC LOG	SAMPLES FOR TESTING	CLASSIFICATION AND PHYSICAL CONDITION
Hole Completion: Set 14" PVC to 486', perforated 349' - 486'. Placed rubber sleeve and cement plug bottomed at 349'.									102.5'			102.5' - 160.1': Shale. Fresh; greenish gray; clayey to silty. 124.8' - 137.4': Carbonaceous Shale. Black. 125.9' - 127.1': Coal. 131.0' - 131.7': Coal.
	110								10			
	120	93	60						20			
			30						125.9'			
		100							127.1'			
	130		80						131.0' 30 131.7'			
	140		30						40			
		100	55									
	150								50			
		100										
		100	90						60			
	160								160.1'			160.1' - 182.2': Sandstone. Fresh; greenish gray; fine to coarse grained.
		100	20						70			
	170											
		100										
	180		25						80			
		91							182.2' 183.1' 185.1'			182.2' - 192.9': Shale. Fresh; greenish gray; clayey to silty. Contains less than 5% thin carbonaceous laminae. 183.1' - 185.1': Coal.
	190	100	40						90			
									192.9'			192.9' - 207.8': Sandstone. Fresh; greenish gray; fine to coarse grained. Contains about 2% thin carbonaceous laminae.
			45									

EXPLANATION

CORE LOSS

CORE RECOVERY

Type of hole . . . . . D = Diamond, H = Haystellite, S = Shot, C = Churn
Hole sealed . . . . . P = Packer, Cm = Cemented, Cs = Bottom of casing

Approx. size of hole (X-series) . .	Ex = 1-1/2",	Ax = 1-7/8",	Bx = 2-3/8",	Nx = 3"
Approx. size of core (X-series) . .	Ex = 7/8",	Ax = 1-1/8",	Bx = 1-5/8",	Nx = 2-1/8"
Outside dia. of casing (X-series).	Ex = 1-13/16",	Ax = 2-1/4",	Bx = 2-7/8",	Nx = 3-1/2"
Inside dia. of casing (X-series). .	Ex = 1-1/2",	Ax = 1-29/32",	Bx = 2-3/8",	Nx = 3"

* GPO 778-404

7-1887 (6-74)
Bureau of Reclamation

GEOLOGIC LOG OF DRILL HOLE

FEATURE: Kimbeto Study Site | PROJECT: EMRIA | STATE: New Mexico
HOLE NO.: DH-10K | LOCATION: San Juan County | GROUND ELEV.: 6,431.2' | DIP (ANGLE FROM HORIZ.): 90 degrees
COORDS. N. ..... E. ..... | --
BEGUN: 9-12-77 | FINISHED: 9-24-77 | DEPTH OF OVERBURDEN: ..... | TOTAL DEPTH: 500.0' | BEARING: .....
DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED: See Notes | LOGGED BY: W. Witt | LOG REVIEWED BY: J. Jackson

NOTES ON WATER LOSSES AND LEVELS, CASING, CEMENTING, CAVING, AND OTHER DRILLING CONDITIONS	TYPE AND SIZE OF HOLE	CORE RECOVERY (%)	PERCOLATION TESTS: DEPTH (FEET) FROM / TO	LOSS (G.P.M.)	PRESSURE (P.S.I.)	LENGTH OF TEST (MIN.)	ELEVATION (FEET)	DEPTH (FEET)	GRAPHIC LOG	SAMPLES FOR TESTING	CLASSIFICATION AND PHYSICAL CONDITION
			Coring Time (Mins.)					207.8'			207.8' - 211.2': Shale. Fresh; dark greenish gray; clayey to silty.
	210	77	35					211.2'			211.2' - 217.2': Sandstone. Fresh; greenish gray; medium grained.
	220	100	35					217.2'			217.2' - 224.5': Shale. Fresh; light to dark greenish gray; clayey to silty.
	230	95						224.5'			224.5' - 238.0': Sandstone. Fresh; light greenish gray; fine to medium grained.
	240	100	40					238.0' 238.2' 240.4'			238.0' - 247.5': Shale. Fresh; greenish gray; clayey to silty. 238.2' - 240.3': Coal.
	Nx	89	60					247.5'			247.5' - 262.3': Sandstone. Fresh; greenish gray; fine grained.
	250		40								
	260							262.3'			262.3' - 265.8': Shale. Fresh; greenish gray; clayey to silty.
	270	100	45					265.8'			265.8' - 280.4': Sandstone. Fresh, greenish gray; fine to medium grained.
	280		35					280.4' 281.0' 288.4'			280.4' - 292.9': Shale. Fresh; greenish gray; clayey to silty. 281.0' - 288.4': Coal. 288.4' - 292.9': Carbonaceous Shale.
	290		20					292.9'			292.9' - 339.9': Sandstone. Fresh; greenish gray; fine to medium grained.

EXPLANATION

CORE LOSS
CORE RECOVERY

Type of hole ..... D = Diamond, H = Haystellite, S = Shot, C = Churn
Hole sealed ..... P = Packer, Cm = Cemented, Cs = Bottom of casing
Approx. size of hole (X-series) .. Ex = 1-1/2", Ax = 1-7/8", Bx = 2-3/8", Nx = 3"
Approx. size of core (X-series) .. Ex = 7/8", Ax = 1-1/8", Bx = 1-5/8", Nx – 2-1/8"
Outside dia. of casing (X-series). Ex = 1-13/16", Ax = 2-1/4", Bx = 2-7/8", Nx = 3-1/2"
Inside dia. of casing (X-series).. Ex = 1-1/2", Ax = 1-29/32", Bx = 2-3/8", Nx = 3"

* GPO 778-404

7-1837 (6-74)
Bureau of Reclamation

GEOLOGIC LOG OF DRILL HOLE

FEATURE . . Kimbeto Study Site . . . . . PROJECT . . EMRIA . . . . . STATE . . New Mexico . . . . . .

HOLE NO. . DH-10K . . LOCATION. San Juan County . . . . . GROUND ELEV. . 6,431.2' . . . . . DIP (ANGLE FROM HORIZ.) . . 90 degrees . . . . . .

COORDS. N. . . . . E. . . . . .

BEGUN . . 9-12-77. . FINISHED. . 9-24-77 . . . DEPTH OF OVERBURDEN . . -- . . . . . TOTAL DEPTH. 500.0' . . . BEARING. . . . . .

DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED . . See Notes . . . . . LOGGED BY . . W. Witt . . . . . LOG REVIEWED BY. J. Jackson . . . . . .

NOTES ON WATER LOSSES AND LEVELS, CASING, CEMENTING, CAVING, AND OTHER DRILLING CONDITIONS	TYPE AND SIZE OF HOLE	CORE RECOVERY (%)	PERCOLATION TESTS: DEPTH (FEET) FROM	PERCOLATION TESTS: DEPTH (FEET) TO	PERCOLATION TESTS: LOSS (G.P.M.)	PERCOLATION TESTS: PRESSURE (P.S.I.)	PERCOLATION TESTS: LENGTH OF TEST (MIN.)	ELEVATION (FEET)	DEPTH (FEET)	GRAPHIC LOG	SAMPLES FOR TESTING	CLASSIFICATION AND PHYSICAL CONDITION
			Coring Time (Mins.)									
		100										
			25									
		97										
		98										
			30									
		97							339.9			339.9' - 340.0': Coal.
									340.0			
									342.7			340.0' - 342.7': Carbonaceous Shale.
									346.3			342.7' - 346.3': Shale. Fresh; greenish gray; silty.
		96							350.2			346.3' - 421.2': Sandstone. Fresh; greenish gray; fine to medium grained.
									351.3			350.2 - 351.3': Coal.
			180									
		100										
		100										
			35									
		100										

EXPLANATION

CORE LOSS

CORE RECOVERY

Type of hole . . . . . D = Diamond, H = Haystellite, S = Shot, C = Churn
Hole sealed . . . . . P = Packer, Cm = Cemented, Cs = Bottom of casing
Approx. size of hole (X-series) . . Ex = 1-1/2", Ax = 1-7/8", Bx = 2-3/8", Nx = 3"
Approx. size of core (X-series) . . Ex = 7/8", Ax = 1-1/8", Bx = 1-5/8", Nx = 2-1/8"
Outside dia. of casing (X-series). Ex = 1-13/16", Ax = 2-1/4", Bx = 2-7/8", Nx = 3-1/2"
Inside dia. of casing (X-series). . Ex = 1-1/2", Ax = 1-29/32", Bx = 2-3/8", Nx = 3"

* GPO 778-404

7-1887 (6-74)
Bureau of Reclamation

GEOLOGIC LOG OF DRILL HOLE

FEATURE: Kimbeto Study Site | PROJECT: EMRIA | STATE: New Mexico
HOLE NO.: DH-10K | LOCATION: San Juan County | GROUND ELEV.: 6,431.2' | DIP (ANGLE FROM HORIZ.): 90 degrees
BEGUN: 9-12-77 | FINISHED: 9-24-77 | COORDS. N: | E: | DEPTH OF OVERBURDEN: -- | TOTAL DEPTH: 500.0' | BEARING:
DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED: See Notes | LOGGED BY: W. Witt | LOG REVIEWED BY: J. Jackson

NOTES ON WATER LOSSES AND LEVELS, CASING, CEMENTING, CAVING, AND OTHER DRILLING CONDITIONS	TYPE AND SIZE OF HOLE	CORE RECOVERY (%)	PERCOLATION TESTS: DEPTH (FEET) FROM	TO	LOSS (G.P.M.)	PRESSURE (P.S.I.)	LENGTH OF TEST (MIN.)	ELEVATION (FEET)	DEPTH (FEET)	GRAPHIC LOG	SAMPLES FOR TESTING	CLASSIFICATION AND PHYSICAL CONDITION
			Coring Time (Mins.)									
		96		65					10			
	410	80							20			
	420								421.2			421.2' - 446.7': Interbedded Sandstone and Shale. Fresh; 50-50 alternating 1" to 0.2' beds.
		100		90					30			
	430								40			
	440	99		90								
	Nx			90					446.7			446.7' - 461.2': Sandstone. Fresh; fine grained; light greenish gray.
	450			120					50			
	460								461.2			461.2' - 469.0': Shale. Fresh; silty; greenish gray.
				120					60			
	470	100							469.0			469.0' - 500.0': Sandstone. Fresh; greenish gray, fine grained with silty streaks.
				120					70			
	480								80			
				120								
	490								90			
				110								
									500.0			

EXPLANATION

CORE LOSS
CORE RECOVERY

Type of hole . . . . . D = Diamond, H = Haystellite, S = Shot, C = Churn
Hole sealed . . . . . P = Packer, Cm = Cemented, Cs = Bottom of casing
Approx. size of hole (X-series) . . Ex = 1-1/2", Ax = 1-7/8", Bx = 2-3/8", Nx = 3"
Approx. size of core (X-series) . . Ex = 7/8", Ax = 1-1/8", Bx = 1-5/8", Nx = 2-1/8"
Outside dia. of casing (X-series). Ex = 1-13/16", Ax = 2-1/4", Bx = 2-7/8", Nx = 3-1/2"
Inside dia. of casing (X-series). . Ex = 1-1/2", Ax = 1-29/32", Bx = 2-3/8", Nx = 3"

* GPO 778-404

SECTION O

COAL RESOURCES APPENDIX

SECTION O

COAL RESOURCES APPENDIX

Origin of Coal

Coal has been defined as "a readily combustible rock containing more than 50 percent by weight and more than 70 percent by volume of carbonaceous material, formed from compaction or induration of variously altered plant remains similar to those of peaty deposits. Differences in the kinds of plant materials (type), in degree of metamorphism (rank), and range of impurity (grade) are characteristics of the varieties of coal" (Schopf, 1966, p. 588). Inherent in the definition is the specification that the coal originated as a mixture of organic plant remains and inorganic mineral matter that accumulated in a manner similar to that in which modern-day peat deposits are formed. The peat underwent a long, complex process called "coalification", during which diverse physical and chemical changes occurred as the peat changed to coal and as the coal assumed the characteristics by which members of the series are differentiated from each other. The factors that affect the composition of coals have been summarized by Francis (1961, p. 2) as follows:

1) The mode of accumulation and burial of the plant debris forming the deposit.

2) The age of the deposits and their geographical distribution.

3) The structure of the coal-forming plants, particularly details of structure that affect chemical composition or resistance to decay.

4) The chemical composition of the coal-forming debris and its resistance to decay.

5) The nature and intensity of the plant-decaying agencies.

6) The subsequent geological history of the residual products of decay of the plant debris forming the deposits.

For extended discussion of these factors the reader is referred to such standard works as Moore (1940), Lowry (1945), Tomkeieff (1954), Francis (1961), and Lowry (1963).

Classification of Coal

Coals can be classified in many ways (Tomkeieff, 1954, p. 9; Moore, 1940, p. 113; Francis, 1961, p. 361), but the classification by rank, that is, by degree of metamorphism in the progressive series that begins with peat and ends with graphocite (Schopf, 1966), is the most commonly used system. Classification by types of plant materials is commonly used as a descriptive adjunct to rank classification when sufficient megascopic and microscopic information is available, and classification by type and quantity of impurities (grade) is also frequently used when utilization of the coal is being considered. Other categorizations are possible and are commonly employed in discussion of coal resources. Factors such as weight of the coal, thickness and areal extent of individual coal beds, and the thickness of overburden are generally considered.

Rank of Coal

The position of a coal within the metamorphic series, which begins with peat and ends with graphocite, is dependent upon the temperature and pressure to which the coal has been subjected and the duration of time of subjection. Because it is, by definition, largely derived from plant material, coal is mostly composed of carbon, hydrogen, and oxygen, along with smaller quantities of nitrogen, sulfur, and other elements. The increase in rank of coal as it undergoes progressive metamorphism is indicated by changes in the proportions of the coal constitutients--the higher rank coals have more carbon and less hydrogen than the lower ranks.

Two standardized forms of coal analyses--the proximate analysis and the ultimate analysis--are generally used, though sometimes only the less complicated and less expensive proximate analysis is made. The analyses are described as follows (U.S. Bureau of Mines, 1965, p. 121-122):

> The proximate analysis of coal involves the determination of four constituents: (1) water, called moisture; (2) mineral impurity, called ash, left when the coal is completely burned; (3) volatile matter, consisting of gases or vapors driven out when coal is heated to certain temperatures; and (4) fixed carbon, the solid or cokelike residue that burns at higher temperatures after volatile matter has been driven off. Ultimate analysis involves the determination of carbon and hydrogen as found in the gaseous products of combustion, the determination of sulfur, nitrogen, and ash in the material as a whole, and the estimation of oxygen by difference.

Most coals are burned to produce heat energy so the heating value of the coal is an important property. The heating value (calorific value) is commonly expressed in British thermal units (Btu) per pound: one Btu is the amount of heat required to raise the temperature of 1 pound of water 1 degree fahrenheit (in the metric system, heating value is expressed in kilogram-calories per kilogram). Additional tests are sometimes made, particularly to determine the caking, coking, and other properties, such as tar yield, which affect classification or utilization.

Figure 0-1 compares, in histogram form, the heating values and moisture, volatile matter, and fixed carbon contents of coals of different ranks.

Various schemes for classifying coals by rank have been proposed and used, but the most commonly employed is that entitled "Standard specifications for classification of coals by rank," adopted by the American Society for Testing and Materials (1974) (table 0-1).

The ASTM classification system differentiates coals into classes and groups on the basis of mineral-matter-free fixed carbon or volatile matter and the heating value, supplemented by determination of agglomerating (caking) characteristics. As pointed out by the ASTM (1974, p. 55), a standard rank determination cannot be made unless the samples were obtained in accordance with standardized sampling procedures (Snyder, 1950; Schopf, 1960). However, nonstandard samples may be used for comparative purposes through determinations designated as "apparent rank."

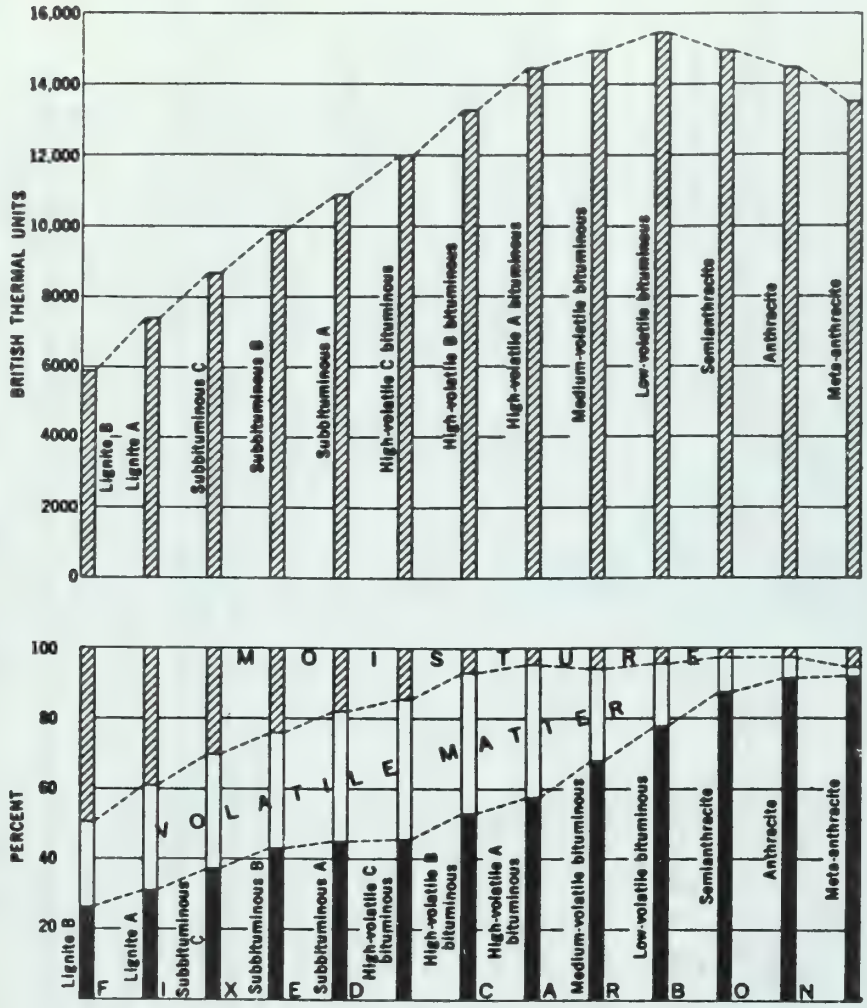


FIGURE 0-1--COMPARISON ON MOIST, MINERAL-MATTER-FREE BASIS OF HEAT VALUES AND PROXIMATE ANALYSES OF COAL OF DIFFERENT RANKS

Table 0-1.--Classification of coals by rank[1]

[American Society for Testing and Materials Standard D388-66; (Reapproved 1972); 1 Btu equals 0.252 kilogram-calories. Leaders (--) indicate category is not used in rank determination of group]

Class	Group	Fixed carbon limits, percent (dry, mineral-matter-free basis)		Volatile matter limits, percent (dry, mineral matter-free basis)		Calorific value limits, Btu per pound (moist[2], mineral-matter-free basis)		Agglomerating character
		Equal or greater than	Less than	Greater than	Equal or less than	Equal or greater than	Less than	
I. Anthracitic	1. Meta-anthracite	98	--	--	2	--	--	
	2. Anthracite	92	98	2	8	--	--	nonagglomerating
	3. Semianthracite[3]	86	92	8	14	--	--	
II. Bituminous	1. Low volatile bituminous coal	78	86	14	22	--	--	
	2. Medium volatile bituminous coal	69	78	22	31	--	--	
	3. High volatile A bituminous coal	--	69	31	--	14,000[4]	--	commonly agglomerating[5]
	4. High volatile B bituminous coal	--	--	--	--	13,000[4]	14,000	
	5. High volatile C bituminous coal	--	--	--	--	11,500	13,000	
						10,500	11,500	agglomerating
III. Subbituminous	1. Subbituminous A coal	--	--	--	--	10,500	11,500	
	2. Subbituminous B coal	--	--	--	--	9,500	10,500	
	3. Subbituminous C coal	--	--	--	--	8,300	9,500	
								nonagglomerating
IV. Lignitic	1. Lignite A	--	--	--	--	6,300	8,300	
	2. Lignite B					--	6,300	

[1]This classification does not include a few coals, principally nonbanded varieties, that have unusual physical and chemical properties and that come within the limits of fixed carbon or calorific value of the high-volatile bituminous and subbituminous ranks. All of these coals either contain less than 48 percent dry, mineral-matter-free fixed carbon or have more than 15,500 moist, mineral-matter-free British thermal units per pound.

[2]Moist refers to coal containing its natural inherent moisture but not including visible water on the surface of the coal.

[3]If agglomerating, classify in low-volatile group of the bituminous class.

[4]Coals having 69 percent or more fixed carbon on the dry, mineral-matter-free basis are classified according to fixed carbon, regardless of calorific value.

[5]It is recognized that there may be nonagglomerating varieties in these groups of the bituminous class and that there are notable exceptions in the high-volatile C bituminous group.

Type of coal

Classification of coals by type--that is, according to the types of plant materials present--takes many forms, such as the "rational analysis" of Francis (1961) or the semicommercial "type" classification commonly used in the coal fields of the eastern United States (U.S. Bureau of Mines, 1965, p. 123). However, most of the type classifications are based on the same, or similar, gross distinctions in plant material as those used by Tomkeieff (1954, Table II and p. 9), who divided the coals into three series: humic coals, humic-sapropelic coals, and sapropelic coals, based upon the nature of the original plant materials. The humic coals are largely composed of the remains of the woody parts of plants and the sapropelic coals are largely composed of the more resistant waxy, fatty, and resinous parts of plants, such as cell walls, spore-coatings, pollen, resin particles, and coals composed mainly of algal material. Most coals fall into the humic series, with some coals being a mixture of humic and sapropelic elements and, therefore, falling into the humic-sapropelic series. The sapropelic series is quantitatively insignificant and, when found is commonly regarded as an organic curosity. In common with most of the U.S. coals, those from the Kimbeto EMRIA study site fall largely in the humic series.

Grade of coal

Classification of coal by grade, or quality, is based largely on the content of ash, sulfur, and other constituents that adversely affect utilization. Most detailed coal resource evaluations of the past do not categorize known coal resources by grade; however coals of the United States have been classified by sulfur content in a gross way (DeCarlo and others, 1966)

The range and average of the ash and sulfur content of 642 coals from all parts of the United States were determined by Fieldner, Rice, and Moran (1942):

Ash and sulfur contents of U.S. coals on an as-received basis

Number of samples	Ash, percent		Sulfur, percent	
	Range	Average	Range	Average
642	2.5-32.6	8.9	0.2-7.7	1.9

Table 0-2.--Estimated identified subbituminous coal resources of the Fruitland Formation, Kimbeto EMRIA study site, San Juan County, N. Mex. as of January 1, 1979

[Leaders (---) indicate not present. In thousands of tons. 1 foot = 0.305 meters; 1 short ton = 0.907 metric ton]

Location		0-200 ft overburden												Section total
		2 1/2 - 5 feet				5-10 feet				10 ft or more				
		Measured	Indicated	Inferred	Total	Measured	Indicated	Inferred	Total	Measured	Indicated	Inferred	Total	
T. 22 N., R. 9 W.														
S ½	sec. 19	----	----	----	----	96	1,357	----	1,453	----	----	----	----	1,453
	sec. 30	13	675	1,549	2,237	----	689	4,983	5,672	----	----	----	----	7,909
T. 22 N., R. 10 W.														
	sec. 4	----	----	----	----	----	----	----	----	----	----	----	----	----
	sec. 5	----	----	----	----	42	3,549	3,321	6,912	----	----	----	----	6,912
S ½	sec. 6	268	1,325	----	1,593	1,980	8,277	----	10,257	----	----	----	----	11,850
	sec. 7	688	3,120	----	3,808	2,353	7,944	----	10,297	3,375	13,842	----	17,217	31,322
	sec. 8	----	319	117	436	----	4,766	5,235	10,001	----	9,934	13,925	23,859	34,296
	sec. 9	----	----	----	----	----	303	----	303	791	11,345	----	12,136	12,439
SW ¼	sec. 10	----	----	----	----	----	----	----	----	4,590	2,450	----	7,040	7,040
SW ¼	sec. 11	----	----	----	----	----	144	632	776	----	765	3,240	4,005	4,781
SW ¼	sec. 13	----	----	----	----	765	2,781	----	3,546	20	1,435	----	1,455	5,001
	sec. 14	----	----	----	----	362	4,012	3,650	8,024	1,221	9,120	8,029	18,370	26,394
	sec. 15	441	2,315	739	3,495	----	218	48	266	3,375	22,457	5,650	31,482	35,243
Leased	sec. 16	(data not released)												
	sec. 17	438	3,477	624	4,539	----	4,435	1,062	5,497	3,308	16,443	4,014	23,705	33,801
	sec. 18	1,918	2,508	----	4,426	3,938	10,345	----	14,283	4,155	5,620	----	9,775	28,484
	sec. 19	216	1,804	1,578	3,598	----	4,760	14,467	19,227	----	----	----	----	22,825
	sec. 22	63	1,379	2,756	4,198	324	2,447	4,405	6,976	1,145	8,136	1,986	11,207	22,441
	sec. 23	61	1,069	1,651	2,781	345	5,389	6,026	11,760	1,350	6,002	365	7,717	22,258
	sec. 24	253	947	83	1,283	2,701	10,735	3,632	17,068	21	423	----	444	18,795
	sec. 25	423	3,162	387	3,972	----	----	17,650	17,650	----	----	----	----	21,622
N ½	sec. 26	----	73	2,055	2,128	----	----	7,408	7,408	----	----	----	----	9,536
NE ¼	sec. 27	----	----	1,238	----	----	----	3,679	3,679	----	----	----	----	4,917
T. 22 N., R. 11 W.														
	sec. 12	395	4,550	1,297	6242	----	1,415	5,943	7,358	----	----	----	----	13,600
Total for Area		5,177	26,915	14,415	46,507	13,130	75,446	82,134	170,710	25,120	135,517	42,187	202,824	420,041

Table O-2.--Estimated identified subbituminous coal resources of the Fruitland Formation, Kimbeto EMRIA study site, San Juan County, N. Mex. as of January 1, 1979--Continued

Location		200-400 feet												Section total
		2 1/2 - 5 feet				5-10 feet				10 feet or more				
		Measured	Indicated	Inferred	Total	Measured	Indicated	Inferred	Total	Measured	Indicated	Inferred	Total	
						T. 22 N., R. 9 W.								
S ½	sec. 19	----	----	----	----	----	----	----	----	----	----	----	----	----
	sec. 30	----	----	----	----	----	----	----	----	----	----	----	----	----
						T. 22 N., R. 10 W.								
	sec. 4	361	1,058	243	1,662	----	----	----	----	3,868	23,700	10,629	38,197	39,859
	sec. 5	452	830	20	1,302	----	----	----	----	3,822	20,257	6,364	30,443	31,745
S½	sec. 6	----	----	----	----	----	----	----	----	1,219	6,525	----	7,744	7,744
	sec. 7	----	----	----	----	----	----	----	----	1,570	7,091	----	8,661	8,661
	sec. 8	----	2,030	1,682	3,712	----	----	----	----	----	12,730	10,667	23,397	27,109
	sec. 9	1,478	4,173	----	5,651	----	----	----	----	8,947	24,849	----	33,796	39,447
SW ¼	sec. 10	----	95	----	95	15	31	----	46	424	1,418	----	1,842	1,983
SW ¼	sec. 11	----	----	----	----	----	----	30	30	----	----	----	----	30
SW ¼	sec. 13	----	----	----	----	238	1,235	----	1,473	----	----	----	----	1,473
	sec. 14	----	----	----	----	548	3,675	2,537	6,760	----	----	----	----	6,760
	sec. 15	----	----	----	----	438	4,636	936	6,010	----	----	----	----	6,010
Leased	sec. 16													
	sec. 17	----	360	21	381	----	----	----	----	305	3,088	298	3,691	4,072
	sec. 18	----	----	----	----	----	----	----	----	17	280	----	297	297
	sec. 19	----	----	----	----	----	----	----	----	----	----	----	----	----
	sec. 22	----	----	----	----	464	2,805	2,185	5,454	----	----	----	----	5,454
	sec. 23	----	----	----	----	486	2,952	1,787	5,225	----	----	----	----	5,225
	sec. 24	----	----	----	----	726	2,337	215	3,278	----	----	----	----	3,278
	sec. 25	----	----	----	----	----	----	----	----	----	----	----	----	----
N ½	sec. 26	----	----	----	----	----	----	310	310	----	----	----	----	310
NE ¼	sec. 27	----	----	----	----	----	----	164	164	----	----	----	----	164
						T. 22 N., R. 11 W.								
	sec. 12	----	----	----	----	----	----	----	----	----	----	----	----	----
Total for Area		2,291	9,091	1,966	13,348	2,915	18,873	9,092	30,880	20,452	103,236	28,009	151,697	195,925

Chemical Analyses of Coal and Coaly Shale in the Fruitland Formation Kimbeto Study Site

Unweighed statistical summaries of analytical data on the 14 coal samples in tables D-2, 0-3, and 0-4, are listed in tables 0-7, 0-8, and 0-9, respectively. For comparison, data summaries of proximate, ultimate, forms-of-sulfur analyses, and heat of combustion for 86 other Rocky Mountain province coal samples (Swanson and others, 1976) and data summaries of major, minor, and trace elements for 79 other San Juan River region coal samples (Hatch and Swanson, 1977), are included. Data summaries for Cd, Ge, La, and Nd were not made because they were detected in an insufficient number of samples to calculate meaningful statistics.

To be consistent with the precision of the semiquantitative emission spectrographic technique, arithmetic and geometric means of elements determined by this method are reported as the mid-point of the enclosing six-step bracket (see headnote of table 0-3, or Swanson and Huffman, 1976, p. 6, for an explanation of six-step brackets).

Explanation of statistical terms used in summary tables

In this report the geometric mean (GM) is used as the estimate of the most probable concentration (mode); the geometric mean is calculated by taking the logarithm of each analytical value, summing the logarithms, dividing the sum by the total number of values, and obtaining the antilogarithm of the result. The measure of scatter about the mode used here is the geometric deviation (GD), which is the antilog of the standard deviation of the logarithms of the analytical values. These statistics are used because the quantities of trace elements in natural materials commonly exhibit positively skewed frequency distributions; such distributions are normalized by analyzing and summarizing trace-element data on a logarithmic basis.

If the frequency distributions are lognormal, the geometric mean is the best estimate of the mode, and the estimated range of the central two-thirds of the observed distribution has a lower limit equal to GM/GD and an upper limit equal to GM GD. The estimated range of the central 95 percent of the observed distribution has a lower limit equal to $GM/(GD)^2$ and an upper limit equal to $GM\ (GD)^2$ (Connor and others, 1976).

Although the geometric mean is, in general, an adequate estimate of the most common analytical value, it is, nevertheless, a biased estimate of the arithmetic mean. The estimates of the arithmetic means listed in the summary tables are Sichel's t statistic (Miesch, 1967).

A common problem in statistical summaries of trace-element data arises when the element content of one or more of the samples is below the limit of analytical detection. This results in a "censored" distribution. Procedures developed by Cohen (1959) were used to compute unbiased estimates of the geometric mean, geometric deviation, and arithmetic mean when the data are censored.

Table 0-3.--Major- and minor-oxide and trace-element composition of the laboratory ash of 17 coal and shale samples from the Fruitland Formation, Kimbeto study site, San Juan County, N. Mex.

[Values in percent or parts per million. Coal ashed at 525°C. L means less than the value shown; N, not detected; B, not determined. S after element title indicates determinations by semiquantative emission spectrography. The emission spectrographic results are to be identified with geometric brackets whose boundaries are part of the ascending series 0.12, 0.18, 0.26, 0.38, 0.56, 0.83, 1.2, etc., but reported as mid-points of the brackets, 0.1, 0.15, 0.2, 0.3, 0.5, 0.7, 0.1, etc. Precision of the spectrographic data is plus-or-minus one bracket at 68 percent or plus-or-minus two brackets at 95 percent confidence level]

Sample number	Ash (percent)	SiO2 (percent)	Al2O3 (percent)	CaO (percent)	MgO (percent)	Na2O (percent)	K2O (percent)	Fe2O3 (percent)	TiO2 (percent)	SO3 (percent)	Sample number
D194012	18.1	60	27	2.2	0.57	2.11	0.39	2.7	1.3	4.3	D194012
D194013	79.0	74	19	.46	1.23	1.83	1.5	4.0	.61	1.0L	D194013
D194014	52.8	74	20	.56	.84	1.77	.87	2.9	.57	1.0L	D194014
D194015	28.6	64	27	1.5	.61	1.61	.48	2.2	1.2	2.9	D194015
D194016	13.5	52	26	2.8	.77	2.91	.17	4.2	1.0	5.6	D194016
D194017	10.3	53	22	6.3	.61	2.61	.48	3.3	1.3	11	D194017
D194018	20.8	53	30	3.0	.42	1.34	.46	2.8	1.3	4.9	D194018
D194019	32.8	67	23	1.4	.73	1.44	.46	3.7	.98	2.6	D194019
D194020	28.9	65	26	1.1	.64	1.61	.82	2.0	.88	2.1	D194020
D194021	36.9	65	24	1.0	.81	1.57	.82	2.4	.82	1.7	D194021
D194022	28.1	66	23	1.1	.86	1.74	.99	2.7	.90	2.6	D194022
D194023	25.3	58	26	2.5	.52	1.21	.82	3.0	1.1	3.0	D194023
D194024	32.3	68	21	1.3	.73	1.62	1.2	2.7	1.0	2.2	D194024
D194025	29.8	65	23	1.3	.77	1.57	.77	2.7	1.0	2.4	D194025
D194026	33.9	66	26	.89	.70	1.59	.70	2.5	.89	1.7	D194026
D194027	75.2	73	16	.33	1.32	1.87	2.3	5.9	.68	1.5	D194027
D194028	23.8	58	28	2.4	.47	1.47	.49	2.1	1.1	2.9	D194028

Sample number	B-S (ppm)	Ba-S (ppm)	Be-S (ppm)	Cd (ppm)	Cu (ppm)	Ga-S (ppm)	Ge-S (ppm)	La-S (ppm)	Li (ppm)	Mn (ppm)	Sample number
D194012	500	700	20	1.0	69	70	30	100L	100	54	D194012
D194013	70	500	3	1.0L	25	30	N	100L	30	74	D194013
D194014	100	500	10	1.0L	28	20	20L	100L	41	30	D194014
D194015	300	500	10	1.0L	78	70	N	100L	96	52	D194015
D194016	500	1,000	10	1.0L	54	50	20L	100L	232	110	D194016
D194017	700	1,500	30	1.0L	133	70	50	150	80	310	D194017
D194018	300	700	3	1.0	81	70	N	100L	105	190	D194018
D194019	300	500	10	1.0L	54	50	N	100L	85	56	D194019
D194020	300	700	7	1.0L	43	50	N	100L	96	52	D194020
D194021	200	500	15	1.0L	54	50	N	100L	72	54	D194021
D194022	300	700	5	1.0L	43	50	N	100L	105	74	D194022
D194023	300	500	3	1.0L	60	50	N	100L	78	210	D194023
D194024	300	500	15	1.0L	54	30	N	100L	109	380	D194024
D194025	300	500	15	1.0L	54	70	N	100L	80	110	D194025
D194026	200	500	7	1.0L	37	50	N	100L	75	40	D194026
D194027	70	300	3	1.0L	25	30	N	100L	41	98	D194027
D194028	300	700	5	1.0	60	70	N	100L	80	135	D194028

Table 0-3.--Major- and minor-oxide and trace-element composition of the laboratory ash of 17 coal and shale samples from the Fruitland Formation, Kimbeto study site, San Juan County, N. Mex.--Continued

Sample number	Mo-S (ppm)	Nb-S (ppm)	Nd-S (ppm)	Ni-S (ppm)	Pb (ppm)	Sc-S (ppm)	Sr-S (ppm)	V-S (ppm)	Y-S (ppm)	Yb-S (ppm)	Sample number
D194012	10	30	N	20	70	30	500	150	100	7	D194012
D194013	N	20L	N	10	30	15	200	70	30	3	D194013
D194014	N	20L	N	10L	30	10	200	70	50	3	D194014
D194015	N	30	N	10	70	15	300	150	50	5	D194015
D194016	N	30	N	20	50	15	700	70	70	7	D194016
D194017	15	30	150	70	75	50	1,000	200	150	15	D194017
D194018	10	30	N	15	70	15	300	150	30	3	D194018
D194019	7	30	N	20	60	15	200	70	50	3	D194019
D194020	7L	30	N	15	55	10	200	70	50	3	D194020
D194021	7L	30	N	15	55	15	200	100	50	3	D194021
D194022	N	30	N	15	45	15	300	70	30	3	D194022
D194023	7	30	N	10	60	15	200	70	30	3	D194023
D194024	7L	30	N	15	40	15	200	100	50	5	D194024
D194025	7	30	N	20	45	20	300	150	70	7	D194025
D194026	N	30	N	10	55	10	200	70	30	3	D194026
D194027	N	30	N	20	25L	15	150	100	30	3	D194027
D194028	7	30	N	15	70	15	300	150	50	3	D194028

Sample number	Zn (ppm)	Zr-S (ppm)
D194012	36	500
D194013	144	100
D194014	138	150
D194015	46	300
D194016	34	300
D194017	49	300
D194018	54	300
D194019	49	200
D194020	61	200
D194021	109	200
D194022	69	300
D194023	80	200
D194024	49	200
D194025	79	200
D194026	45	150
D194027	97	150
D194028	55	300

Table 0-4.--Content of nine trace elements of 17 coal and shale samples from the Fruitland Formation, Kimbeto EMRIA study site, San Juan County, N. Mex.

[Analyses on air-dried (32°C) coal. Values in parts per million (ppm). B, not determined; L, less than the value shown]

Sample number	As	Co	Cr	F	Hg	Sb	Se	Th	U	Sample number
D194012	1.0	3.1	4.9	40	0.05	1.9	2.5	5.0	4.0	D194012
D194013	2.0	6.3	B	480	.10	1.3	B	12	4.7	D194013
D194014	8.0	5.6	B	180	.11	1.1	B	4.0	2.7	D194014
D194015	1.0	2.3	9.6	75	.07	1.2	2.8	6.0	5.3	D194015
D194016	2.0	1.7	3.8	20	.04	.6	1.7	4.0	2.1	D194016
D194017	1.0	5.3	5.5	30	.03	2.8	1.3	3.0L	2.4	D194017
D194018	1.0	2.3	4.8	80	.07	.6	2.4	3.0	3.2	D194018
D194019	14	2.9	8.0	105	.23	1.2	2.6	11	4.5	D194019
D194020	1.0	2.3	5.5	85	.11	.8	1.5	5.0	3.0	D194020
D194021	1.0	5.5	8.7	155	.13	1.9	2.0	10	5.9	D194021
D194022	1.0	2.2	7.2	110	.07	.5	1.8	6.0	3.5	D194022
D194023	1.0	2.3	6.6	110	.08	.7	2.2	6.0	3.1	D194023
D194024	1.0	3.2	11	115	.04	1.2	2.2	9.0	3.7	D194024
D194025	1.0	4.3	11	135	.07	1.3	2.2	9.0	4.3	D194025
D194026	2.0	1.9	6.2	125	.06	.9	B	9.0	4.1	D194026
D194027	10	8.2	26	410	.11	1.2	B	9.0	4.0	D194027
D194028	7.0	1.9	4.8	80	.10	.6	2.2	6.0	3.4	D194028

Table O-5.--Major-, minor-, and trace-element composition of 17 coal and shale samples from the Fruitland Formation, Kimbeto EMRIA study site, San Juan County, N. Mex.

[Values in percent or parts per million. As, Co, Cr, F, Hg, Sb, Se, Th, and U values are from direct determinations on air-dried (32°C) coal; all other values calculated from analyses of ash. S means analysis by emission spectrography; L, less than the value shown; N, not detected; B, not determined]

Sample number	Si (percent)	Al (percent)	Ca (percent)	Mg (percent)	Na (percent)	K (percent)	Fe (percent)	Ti (percent)	As (ppm)	B-S (ppm)	Sample number
D194012	5.1	2.6	0.28	0.062	0.28	0.059	0.34	0.14	1.0	100	D194012
D194013	27	7.9	.26	.58	1.1	.99	2.2	.29	2.0	50	D194013
D194014	18	5.6	.21	.27	.69	.38	1.1	.18	8.0	50	D194014
D194015	8.5	4.1	.31	.11	.34	.11	.44	.21	1.0	100	D194015
D194016	3.3	1.9	.27	.063	.29	.019	.40	.081	2.0	70	D194016
D194017	2.5	1.2	.46	.038	.20	.041	.24	.080	1.0	70	D194017
D194018	5.1	3.3	.45	.053	.21	.080	.41	.16	1.0	70	D194018
D194019	10	4.0	.33	.14	.35	.13	.85	.19	14	100	D194019
D194020	8.8	4.0	.23	.11	.34	.20	.40	.15	1.0	100	D194020
D194021	11	4.7	.26	.18	.43	.25	.62	.18	1.0	70	D194021
D194022	8.7	3.4	.22	.15	.36	.23	.53	.15	1.0	100	D194022
D194023	6.9	3.5	.45	.079	.23	.17	.53	.17	1.0	70	D194023
D194024	10	3.6	.30	.14	.39	.32	.61	.19	1.0	100	D194024
D194025	9.0	3.6	.28	.14	.35	.19	.56	.18	1.0	100	D194025
D194026	10	4.7	.22	.14	.40	.20	.59	.18	2.0	70	D194026
D194027	26	6.4	.18	.60	1.0	1.4	3.1	.31	10	50	D194027
D194028	6.4	3.5	.41	.067	.26	.097	.35	.16	7.0	70	D194028

Sample number	Ba-S (ppm)	Be-S (ppm)	Cd (ppm)	Co (ppm)	Cr (ppm)	Cu (ppm)	F (ppm)	Ga-S (ppm)	Ge-S (ppm)	Hg (ppm)	Sample number
D194012	150	3	0.18	3.1	4.9	12	40	15	5	0.05	D194012
D194013	500	2	.79L	6.3	B	20	480	20	N	.10	D194013
D194014	300	5	.53L	5.6	B	15	180	10	10L	.11	D194014
D194015	150	3	.29L	2.3	9.6	22	75	20	N	.07	D194015
D194016	150	1.5	.14L	1.7	3.8	7.3	20	7	3L	.04	D194016
D194017	150	3	.10L	5.3	5.5	14	30	7	5	.03	D194017
D194018	150	.7	.21	2.3	4.8	17	80	15	N	.07	D194018
D194019	150	3	.33L	2.9	8.0	18	105	15	N	.23	D194019
D194020	200	2	.29L	2.3	5.5	12	85	15	N	.11	D194020
D194021	200	5	.37L	5.5	8.7	20	155	20	N	.13	D194021
D194022	200	1.5	.28L	2.2	7.2	12	110	15	N	.07	D194022
D194023	150	.7	.25L	2.3	6.6	15	110	15	N	.08	D194023
D194024	150	5	.32L	3.2	11	17	115	10	N	.04	D194024
D194025	150	5	.30L	4.3	11	16	135	20	N	.07	D194025
D194026	150	2	.34L	1.9	6.2	13	125	15	N	.06	D194026
D194027	200	2	.75L	8.2	26	19	410	20	N	.11	D194027
D194028	150	1	.24	1.9	4.8	14	80	15	N	.10	D194028

Table 0-5.--Major-, minor-, and trace-element compositon of 17 coal and shale samples from the Fruitland Formation, Kimbeto EMRTA study site, San Juan County, N. Mex.--Continued

Sample number	La-S (ppm)	Li (ppm)	Mn (ppm)	Mo-S (ppm)	Nb-S (ppm)	Nd-S (ppm)	Ni-S (ppm)	Pb (ppm)	Sb (ppm)	Sc-S (ppm)	Sample number
D194012	20L	18	9.8	2	5	N	3	13	1.9	5	D194012
D194013	70L	24	58	N	15L	N	7	24	1.3	10	D194013
D194014	50L	22	16	N	10L	N	5L	16	1.1	5	D194014
D194015	30L	27	15	N	10	N	3	20	1.2	5	D194015
D194016	15L	31	15	N	5	N	3	6.8	.6	2	D194016
D194017	15	8.2	32	1.5	3	15	7	7.7	2.8	5	D194017
D194018	20L	22	40	2	7	N	3	15	.6	3	D194018
D194019	30L	28	18	2	10	N	7	20	1.2	5	D194019
D194020	30L	28	15	2L	10	N	5	16	.8	3	D194020
D194021	30L	27	20	2L	10	N	5	20	1.9	5	D194021
D194022	30L	30	21	N	10	N	5	13	.5	5	D194022
D194023	20L	20	53	1.5	7	N	2	15	.7	3	D194023
D194024	30L	35	120	2L	10	N	5	13	1.2	5	D194024
D194025	30L	24	33	2	10	N	7	13	1.3	7	D194025
D194026	30L	25	14	N	10	N	3	19	.9	3	D194026
D194027	70L	31	74	N	20	N	15	19L	1.2	10	D194027
D194028	20L	19	32	1.5	7	N	3	17	.6	3	D194028

Sample number	Se (ppm)	Sr-S (ppm)	Th (ppm)	U (ppm)	V-S (ppm)	Y-S (ppm)	Yb-S (ppm)	Zn (ppm)	Zr-S (ppm)	Sample number
D194012	2.5	100	5.0	4.0	30	20	1.5	6.5	100	D194012
D194013	B	150	12.0	4.7	50	20	2	110	70	D194013
D194014	B	100	4.0	2.7	30	30	1.5	73	70	D194014
D194015	2.8	100	6.0	5.3	50	15	1.5	13	100	D194015
D194016	1.7	100	4.0	2.1	10	10	1	4.6	50	D194016
D194017	1.3	100	3.0L	2.4	20	15	1.5	5.0	30	D194017
D194018	2.4	70	3.0	3.2	30	7	.7	11	70	D194018
D194019	2.6	70	11.0	4.5	20	15	1	16	70	D194019
D194020	1.5	70	5.0	3.0	20	15	1	18	70	D194020
D194021	2.0	70	10.0	5.9	30	20	1	40	70	D194021
D194022	1.8	100	6.0	3.5	20	10	1	19	100	D194022
D194023	2.2	50	6.0	3.1	15	7	.7	20	50	D194023
D194024	2.2	70	9.0	3.7	30	15	1.5	16	70	D194024
D194025	2.2	100	9.0	4.3	50	20	2	24	70	D194025
D194026	B	70	9.0	4.1	20	10	1	15	50	D194026
D194027	B	100	9.0	4.0	70	20	2	73	100	D194027
D194028	2.2	70	6.0	3.4	30	10	.7	13	70	D194028

Table O-6.--Elements looked for but not detected in coal and shale samples from the Fruitland Formation, Kimbeto study site, San Juan County, N. Mex.

[Approximate lower detection limits in coal and shale ash, as determined by the six-step spectrographic method of the U.S. Geological Survey are included for all elements except P; the reported lower detection limit of P is for the X-ray spectroscopic method]

Element or oxide	Lower limit of detection in coal ash (ppm)
Ag	1
Au	50
Bi	20
Ce	500
Dy	100
Er	100
Eu	200
Gd	100
Hf	200
Ho	50
In	20
Lu	70
P	4,400
Pd	5
Pr	200
Pt	100
Re	100
Sm	200
Sn	20
Ta	1,000
Tb	700
Te	5,000
Tl	100
Tm	50
W	200

Table 0-7.--Arithmetic mean, observed range, geometric mean, and geometric deviation of proximate and ultimate analyses, heat of combustion, forms of sulfur, and ash-fusion temperatures, of 14 coal samples from the Fruitland Formation, Kimbeto study site, San Juan County, N. Mex.

[For comparison, geometric means for 86 Rocky Mountain province coal samples are included (Swanson and others, 1976, table 33a). All values are in percent except Kcal/Kg, Btu/lb, and ash-fusion temperatures, and are reported on the as-received basis. °C = (°F-32)5/9; Kcal/kg = 9.556 (Btu/lb). Leaders (---) indicate no data.]

	Arithmetic mean	Observed range		Geometric mean	Geometric deviation	Rocky Mountain province geometric mean
		Minimum	Maximum			
Proximate and ultimate analyses						
Moisture	14.6	12.7	16.8	14.5	1.1	10.5
Volatile matter	29.6	25.7	34.5	29.5	1.1	35.7
Fixed carbon	32.4	25.6	41.3	32.0	1.2	41.5
Ash	23.8	9.3	33.2	22.0	1.5	7.7
Hydrogen	5.3	4.8	6.2	5.3	1.1	5.6
Carbon	46.8	37.5	59.4	46.4	1.1	58.9
Nitrogen	1.0	.8	1.2	1.0	1.1	1.1
Oxygen	23.0	21.4	25.4	23.0	1.1	22.4
Sulfur	.5	.4	.7	.5	1.2	.5
Heat of combustion						
Kcal/kg	4,590	3,680	5,790	4,540	1.1	6,180
Btu/lb	8,250	6,620	10,410	8,170	1.1	11,110
Forms of sulfur						
Sulfate	0.03	0.01	0.05	0.02	1.6	0.02
Pyritic	.12	.04	.23	.11	1.6	.11
Organic	.38	.23	.55	.37	1.3	.22
Ash-fusion temperatures, °C						
Initial deformation	1,500	1,325	1,540	1,500	1.1	----
Softening temperature	1,515	1,375	1,540	1,520	1.0	----
Fluid temperature	1,530	1,430	1,540	1,530	1.0	----

Table 0-8.--Arithmetic mean, observed range, geometric mean, and geometric deviation of ash content and contents of 10 major and minor oxides in the laboratory ash of 14 coal samples from the Fruitland Formation, Kimbeto study site, San Juan County, N. Mex.

[For comparison geometric means for 79 other San Juan River region coal samples are included (Hatch and Swanson, 1977, table a. All samples were ashed at 525°C; all analyses except geometric deviation are in percent]

Oxide	Arithmetic mean	Observed range		Geometric mean	Geometric deviation	San Juan River region geometric mean
		Minimum	Maximum			
(Ash)	26	10	37	25	1.4	19.4
SiO_2	62	52	68	61	1.1	53
Al_2O_3	25	21	30	25	1.1	24
CaO	2.0	.90	6.3	1.8	1.7	3.9
MgO	.66	.42	.86	.64	1.2	.84
Na_2O	1.7	1.2	2.9	1.7	1.3	1.4
K_2O	.66	.17	1.2	.59	1.6	.54
Fe_2O_3	2.8	2.0	4.2	2.7	1.2	3.5
TiO_2	1.1	.8	1.3	1.0	1.2	.95
SO_3	3.5	1.7	11	3.1	1.7	3.2

Table 0-9--Arithmetic mean, observed range, geometric mean, and geometric deviation of 35 elements in 14 coal samples from the Fruitland Formation at the Kimbeto EMRIA study site, San Juan County, N. Mex.

[For comparison, geometric means for 79 other San Juan River region coal samples are included. All analyses are in percent or parts per million and are reported on a whole-coal bassis. As, Co, Cr, F, Hg, Sb, Se, Th, and U values used to calculate the statisitics were determined directly on whole coal.. All other values were calculated from determinations made on coal ash. L, less than the value shown]

Element	Arithmetic mean	Observed range		Geometric mean	Geometric deviation	San Juan River region geometric mean
		Minimum	Maximum			
Si	7.8	2.5	11	7.0	1.6	4.8
Al	3.5	1.2	4.7	3.3	1.5	2.4
Ca	.32	.22	.46	.31	1.3	.54
Mg	.11	.04	.18	.10	1.6	.099
Na	.32	.20	.43	.31	1.3	.203
K	.16	.02	.32	.12	2.2	.088
Fe	.49	.24	.85	.47	1.4	.48
Ti	.16	.08	.21	.15	1.3	.097
			Parts per million			
As	2.1	1	14	1.5	2.3	2
B	100	70	100	100	1.2	100
Ba	150	150	200	150	1.1	300
Be	3	.7	5	2	2.0	1
Co	2.9	1.7	5.5	2.7	1.5	2
Cr	7	3.8	11	6.6	1.4	5
Cu	15	7.3	22	15	1.3	12.4
F	90	20	155	79	1.4	92
Ga	15	7	20	15	1.4	7
Hg	.08	.03	.23	.07	1.7	.08
Li	25	8.2	35	23	1.4	17.7
Mn	31	9.8	120	25	1.9	23
Mo	1.5	1.5L	2	1.5	1.3	1
Nb	7	3	10	7	1.5	2
Ni	5	2	7	5	1.5	2
Pb	15	6.8	20	14	1.4	11.7
Sb	1.2	.5	2.8	1	1.7	.4
Sc	5	2	7	5	1.4	3
Se	2.1	1.3	2.8	2.1	1.3	1.9
Sr	70	50	100	70	1.2	100
Th	6.6	3.0L	11	6.0	1.6	4.3
U	3.8	2.1	5.9	3.6	1.3	2.2
V	30	10	50	20	1.5	20
Y	15	7	20	15	1.4	7
Yb	1.5	.7	2	1	1.4	.7
Zn	16	4.6	40	14	1.8	11.1
Zr	70	30	100	70	1.4	50

SECTION P

OVERBURDEN GEOCHEMISTRY APPENDIX

SECTION P

OVERBURDEN GEOCHEMISTRY APPENDIX

Complete Tabulation of Bulk Chemical Data For Kimbeto Overburden Rock Drill Core Samples

The first ten columns in the table P-1 (SiO_2% through MnO%) are determinations by X-ray fluorescence spectrography, a precise technique good for many such major and minor (not trace) elements. "LOI%" (11th column) means "loss on ignition"; this is the water and other volatile components driven off when the sample was fused into a ceramic disc. The remaining columns "B ppm-s" through "Zr ppm-s" are determinations by emission spectrography, a less accurate and precise but more sensitive method good for many trace elements ("-s" means "spectrographic"). Where elements are reported by both methods, the x-ray results are generally to be preferred.

Explanation of the coded eight-character sample identifier:

First character--K denotes Kimbeto

Second character--5 means sample was from hole 1, 9 means sample was from hole 10

Third and fourth characters--these identify the position of the sample in the sequence of 10 ft. intervals down the hole: 01 would denote the sample nearest the surface, 02 the next one down, and so forth.

Fifth character--0, denotes that sample is on the usual 10 ft. spacing; 1, denotes that sample is a "companion" sample to another at the regular 10 ft. spacing, separated by a 6 in. gap.
Sixth character--x indicates that sample is split from another sample (otherwise coded the same) and analyzed separately to test for reliability of analytical methods. Seven samples were split in this manner.

Seventh and eighth characters--the seventh character is the basic rock type into which the sample was classified, by hand-specimen inspection and by simple tests, as follows:

S--sandstone
T--siltstone
C--claystone (shale and very fine grained rocks)

the eighth character is a "modifier" or adjective which further characterizes the basic rock type, as follows:

A--pure
S--sandy
T--silty
C--clayey

Example--the seventeenth sample listed in the table, K5010XSC, is from hole 5, is the uppermost sample from the top taken in the sequence of 10 ft. spacings, is exactly on the 10 ft. pattern (not a companion sample with a 6 in. gap), is an "analytical split" (made by dividing, after grinding and mixing, sample K50100SC, listed immediately above in the table), and was called a "clayey sandstone" during description and classification.

Table P-1
Complete tabulation of bulk chemical data, Kimbeto overburden rock, dry weight basis

Sample	Latitude	Longitude	SiO2%	Al2O3%	T-Fe2O3%	MgO%	CaO%	Na2O%	K2O%	TiO2%	P2O5%
					Sandstones						
K50200SA	36 9 17	107 54 4	61.0	17.5	5.0	.89	4.8	3.0	1.8	.58	.3
K50410SA	36 9 17	107 54 4	64.8	17.0	4.1	.87	.7	1.5	1.5	.68	<.1
K50500SA	36 9 17	107 54 4	72.8	14.3	2.7	.83	1.2	2.5	2.2	.50	<.1
K50600SA	36 9 17	107 54 4	75.9	13.3	1.5	.50	1.3	2.9	2.1	.50	<.1
K51300SA	36 9 17	107 54 4	70.4	14.7	3.5	.85	1.1	2.5	2.7	.58	.2
K51400SA	36 9 17	107 54 4	69.7	14.2	2.7	.66	2.8	2.3	2.6	.80	.2
K5140XSA	36 9 17	107 54 4	69.2	14.1	2.7	.64	2.9	2.3	2.5	.77	.2
K51800SA	36 9 17	107 54 4	92.4	3.2	.4	<.10	<.02	<.2	.9	.13	<.1
K51810SA	36 9 17	107 54 4	68.8	12.9	3.3	.80	3.4	2.0	2.7	.55	.1
K51900SA	36 9 17	107 54 4	66.7	13.6	1.9	.73	5.2	1.8	2.2	.62	.1
K5190XSA	36 9 17	107 54 4	66.9	13.0	1.9	.73	5.1	1.9	2.2	.60	.1
K52200SA	36 9 17	107 54 4	65.8	15.8	2.3	.62	2.6	1.2	2.3	.72	.2
K5220XSA	36 9 17	107 54 4	67.1	16.1	2.3	.70	2.5	1.3	2.4	.73	.2
K92800SA	36 7 22	107 49 46	83.5	7.9	.9	.30	.1	1.2	1.8	.22	<.1
K93200SA	36 7 22	107 49 46	75.2	11.8	2.7	1.00	.7	2.1	2.3	.43	<.1
K50100SC	36 9 17	107 54 4	70.2	15.0	3.4	.92	1.8	2.5	1.7	.74	.2
K5010XSC	36 9 17	107 54 4	70.1	15.1	3.4	.90	1.8	2.5	1.7	.74	.2
K50800SC	36 9 17	107 54 4	65.1	15.9	4.5	1.30	1.1	2.0	3.3	.65	.2
K51700SC	36 9 17	107 54 4	66.4	14.4	3.0	.84	3.5	2.0	2.4	.56	.1
K52100SC	36 9 17	107 54 4	56.1	13.8	2.7	.93	9.0	1.1	2.1	.57	.1
K52900SC	36 9 17	107 54 4	71.3	16.1	2.6	.68	.1	1.3	2.0	.62	<.1
K92100SC	36 7 22	107 49 46	75.5	12.9	2.3	.75	1.0	2.6	2.2	.40	<.1
K92500SC	36 7 22	107 49 46	75.7	11.6	1.9	.73	1.3	1.7	2.2	.34	<.1
K93600SC	36 7 22	107 49 46	76.1	10.1	1.9	.77	3.2	2.2	2.1	.37	<.1
K94100SC	36 7 22	107 49 46	66.7	14.7	3.8	2.20	1.5	1.9	2.1	.46	<.1
K50300ST	36 9 17	107 54 4	72.1	14.1	2.8	.74	1.5	2.5	1.6	.56	<.1
K50700ST	36 9 17	107 54 4	67.8	16.0	3.5	1.10	1.4	2.1	2.3	.65	.1
					Siltstones						
K51600TA	36 9 17	107 54 4	77.4	13.2	1.1	.40	.3	1.7	2.5	.27	<.1
K50310TC	36 9 17	107 54 4	68.5	15.9	3.8	.96	1.2	2.4	1.5	.71	<.1
K51100TC	36 9 17	107 54 4	66.4	16.1	4.9	1.40	.7	1.5	3.5	.66	<.1
K51110TC	36 9 17	107 54 4	67.0	14.9	4.5	1.20	1.7	1.6	3.6	.66	.1
					Claystones						
K52300CA	36 9 17	107 54 4	64.8	18.0	3.6	.97	.4	1.1	2.3	.72	<.1
K52310CA	36 9 17	107 54 4	63.2	16.4	3.3	1.20	2.2	1.0	2.4	.65	.1
K50000CT	36 9 17	107 54 4	48.8	15.9	3.5	.65	1.6	1.2	1.7	.56	<.1
K50900CT	36 9 17	107 54 4	66.0	15.7	5.0	1.10	.8	1.3	4.6	.69	.2
K51000CT	36 9 17	107 54 4	59.3	16.1	4.3	1.50	4.1	1.2	3.6	.65	.1

Table P-1 (con.)
Complete tabulation of bulk chemical data, Kimbeto overburden rock, dry weight basis.

Sample	MnO%	LOI%	Al%-S	B ppm-S	Ba ppm-S	Be ppm-S	Ca%-S	Ce ppm-S	Co ppm-S	Cr ppm-S	Cu ppm-S
Sandstones											
K50200SA	.22	5.3	5.8	12	610	1.6	1.5	110	12	9	13
K50410SA	<.02	8.0	7.4	13	390	2.9	.6	71	6	27	22
K50500SA	<.02	3.3	6.2	17	580	2.0	.7	72	15	13	12
K50600SA	<.02	2.1	6.0	10	700	1.1	1.0	68	5	10	6
K51300SA	<.02	2.9	6.6	16	750	1.8	.9	81	7	23	14
K51400SA	.07	4.3	7.2	11	730	1.9	1.3	74	13	21	14
K5140XSA	.08	4.4	7.3	16	810	1.8	1.5	73	12	21	15
K51800SA	<.02	1.1	.3	6	210	4.1	<.1	<46	2	4	2
K51810SA	.07	5.1	6.9	18	560	1.5	1.5	75	8	20	20
K51900SA	.07	6.5	6.9	17	1,000	1.2	1.5	69	7	17	16
K5190XSA	.08	6.6	5.1	10	710	1.8	1.7	56	6	24	13
K52200SA	.04	6.6	7.1	22	480	2.2	1.2	72	9	24	32
K5220XSA	.04	6.5	2.8	6	320	1.4	.9	75	8	17	26
K92800SA	<.02	1.5	3.2	6	400	2.0	.1	<46	4	8	3
K93200SA	<.02	3.2	5.4	18	540	1.7	.5	<46	6	14	6
K50100SC	<.02	3.6	7.9	11	760	2.1	1.3	100	13	22	24
K5010XSC	<.02	3.5	7.2	17	480	2.3	1.1	88	12	25	20
K50800SC	<.02	5.0	8.8	20	800	3.2	.8	78	8	24	38
K51700SC	.04	6.5	7.7	11	810	2.0	1.7	77	7	51	26
K52100SC	.10	11.8	6.2	13	450	1.5	4.8	89	10	25	27
K52900SC	<.02	5.2	7.4	13	360	1.3	.2	74	12	29	14
K92100SC	<.02	2.4	8.7	11	640	1.6	1.1	73	7	27	16
K92500SC	<.02	3.4	7.7	21	640	1.2	1.1	76	8	19	13
K93600SC	<.02	4.0	4.8	13	470	1.3	1.2	66	5	22	5
K94100SC	<.02	6.1	6.7	14	370	2.6	.9	100	9	24	16
K50300ST	<.02	3.5	7.5	17	670	2.2	1.0	100	7	17	17
K50700ST	<.02	4.5	8.2	16	660	2.3	1.1	110	13	26	26
Siltstones											
K51600TA	<.02	3.0	7.2	16	610	2.9	1.6	140	9	34	38
K50310TC	<.02	5.2	10.0	18	490	3.9	1.1	110	14	20	34
K51100TC	<.02	5.0	8.9	22	530	3.3	.7	100	8	40	46
K51110TC	.04	4.7	6.0	16	550	2.2	.9	85	9	31	33
Claystones											
K52300CA	<.02	7.0	8.9	25	440	3.3	.5	98	25	41	38
K52310CA	<.02	8.4	6.3	14	370	2.2	1.0	110	10	27	36
K50000CT	<.02	24.3	2.6	13	150	1.8	.5	79	5	8	23
K50900CT	<.02	4.2	6.2	13	580	2.2	.6	130	8	31	38
K51000CT	.03	7.7	6.4	20	450	2.5	1.5	<46	9	33	35

Table P-1 (con.)
Complete tabulation of bulk chemical data, Kimbeto overburden rock, dry weight basis.

Sample	Dy ppm-S	Er ppm-S	Eu ppm-S	Fe%-S	Ga ppm-S	Gd ppm-S	Ge ppm-S	K%-S	La ppm-S	Li ppm-S	Mg%-S
					Sandstones						
K50200SA	<10	<4.6	<1.0	2.1	13	<10	<1.0	1.3	38	<100	.46
K50410SA	<10	<4.6	<1.0	2.1	14	11	<1.0	1.3	31	<100	.46
K50500SA	<10	<4.6	<1.0	1.8	14	13	<1.0	1.4	39	<100	.36
K50600SA	<10	<4.6	<1.0	.9	12	<10	<1.0	1.6	37	<100	.21
K51300SA	<10	<4.6	<1.0	1.7	14	<10	<1.0	2.6	37	<100	.40
K51400SA	<10	<4.6	<1.0	1.5	13	<10	<1.0	1.9	41	110	.38
K5140XSA	<10	<4.6	<1.0	1.8	15	<10	2.6	1.7	40	<100	.30
K51800SA	<10	<4.6	<1.0	.4	2	<10	2.9	.4	15	<100	<.06
K51810SA	<10	<4.6	<1.0	2.3	18	16	1.8	2.2	37	<100	.52
K51900SA	<10	<4.6	<1.0	1.5	14	<10	1.5	1.3	47	<100	.34
K5190XSA	<10	<4.6	<1.0	1.0	8	<10	<1.0	1.3	32	<100	.32
K52200SA	<10	<4.6	<1.0	1.4	13	17	1.8	1.4	42	<100	.30
K5220XSA	<10	<4.6	<1.0	.8	7	<10	<1.0	1.5	37	<100	.29
K92800SA	<10	<4.6	<1.0	.4	4	12	<1.0	1.2	29	<100	.11
K93200SA	<10	<4.6	<1.0	.9	8	<10	1.6	1.6	26	<100	.44
K50100SC	14	<4.6	<1.0	2.4	19	22	1.6	1.5	48	<100	.54
K5010XSC	<10	<4.6	1.1	2.1	16	<10	1.3	1.6	45	<100	.46
K50800SC	<10	<4.6	<1.0	3.5	18	<10	1.4	2.6	48	<100	.69
K51700SC	<10	<4.6	<1.0	2.4	14	<10	1.7	1.8	43	<100	.43
K52100SC	<10	<4.6	<1.0	1.7	12	<10	1.1	1.6	42	<100	.46
K52900SC	<10	<4.6	<1.0	1.4	14	<10	1.2	1.5	38	<100	.33
K92100SC	<10	<4.6	1.2	2.2	17	<10	2.0	2.1	42	<100	.42
K92500SC	<10	<4.6	<1.0	2.2	15	<10	1.8	1.9	45	<100	.36
K93600SC	<10	<4.6	<1.0	.7	7	13	<1.0	1.2	36	<100	.39
K94100SC	<10	<4.6	1.1	1.9	13	15	1.3	1.8	48	<100	.97
K50300ST	<10	<4.6	1.0	1.7	13	<10	1.6	1.5	42	<100	.37
K50700ST	<10	<4.6	1.2	2.5	19	22	2.1	2.3	49	<100	.64
					Siltstones						
K51600TA	<10	<4.6	<1.0	3.7	16	<10	<1.0	3.2	48	<100	.82
K50310TC	15	<4.6	<1.0	2.8	21	23	1.5	1.5	56	<100	.64
K51100TC	<10	<4.6	<1.0	3.0	20	24	1.6	3.3	47	<100	.76
K51110TC	<10	<4.6	1.1	2.6	12	17	<1.0	3.0	48	<100	.52
					Claystones						
K52300CA	<10	<4.6	<1.0	2.7	23	25	<1.0	1.8	41	<100	.56
K52310CA	<10	<4.6	<1.0	1.6	15	<10	1.2	1.6	45	<100	.52
K50000CT	<10	<4.6	<1.0	.7	7	<10	6.1	1.0	39	<100	.22
K50900CT	<10	<4.6	1.4	2.4	13	14	<1.0	3.5	54	<100	.54
K51000CT	<10	<4.6	<1.0	2.2	19	<10	<1.0	2.9	48	<100	.69

Table P-1 (con.)
Complete tabulation of bulk chemical data, Kimbeto overburden rock, dry weight basis.

Sample	Mn ppm-S	Mo ppm-S	Na%-S	Nb ppm-S	Nd ppm-S	Ni ppm-S	Pb ppm-S	Pr ppm-S	Sc ppm-S	Si%-S
					Sandstones					
K50200SA	1,300	4.2	1.1	13	<46	10	9	<68	14	19
K50410SA	65	2.6	.5	22	<46	14	13	<68	10	23
K50500SA	59	3.4	1.7	15	<46	18	9	<68	6	27
K50600SA	68	2.2	1.1	11	<46	8	6	<68	5	30
K51300SA	270	2.6	1.3	12	<46	14	12	<68	9	24
K51400SA	660	2.1	1.0	21	<46	19	11	<68	11	26
K5140XSA	600	1.9	.8	18	<46	17	11	<68	10	32
K51800SA	18	2.4	.1	10	<46	2	5	<68	<1	>37
K51810SA	560	2.6	1.7	17	<46	15	12	<68	10	27
K51900SA	550	1.6	.6	15	<46	11	7	<68	8	30
K5190XSA	540	1.6	.5	21	<46	10	6	<68	8	21
K52200SA	310	2.0	.4	20	<46	16	9	<68	9	27
K5220XSA	260	2.3	.5	13	<46	11	6	<68	9	16
K92800SA	21	1.0	.4	10	<46	3	3	<68	4	28
K93200SA	55	1.9	1.2	16	<46	10	8	<68	6	27
K50100SC	93	3.4	.9	17	<46	19	10	<68	13	32
K5010XSC	78	2.6	1.0	17	<46	16	10	<68	12	29
K50800SC	230	3.4	.8	11	<46	19	14	<68	10	30
K51700SC	410	2.2	.8	14	<46	14	10	<68	9	32
K52100SC	780	2.3	.5	18	<46	19	9	<68	12	25
K52900SC	30	1.7	.5	17	<46	19	15	<68	12	28
K92100SC	190	2.9	1.2	17	<46	12	15	<68	8	>37
K92500SC	220	2.4	.7	18	<46	15	14	<68	9	>37
K93600SC	230	1.4	.5	17	<46	9	8	69	7	25
K94100SC	90	2.4	.9	25	<46	18	15	<68	11	23
K50300ST	270	1.8	1.1	20	<46	10	14	<68	7	31
K50700ST	300	2.7	1.0	19	<46	20	19	<68	13	33
					Siltstones					
K51600TA	350	5.0	.7	22	<46	21	17	<68	14	23
K50310TC	180	3.0	1.1	23	<46	19	37	<68	10	35
K51100TC	190	2.9	.8	19	<46	22	20	<68	14	30
K51110TC	330	3.0	1.2	20	<46	17	11	<68	14	23
					Claystones					
K52300CA	56	2.7	.5	24	<46	54	25	<68	16	33
K52310CA	180	2.3	.3	19	<46	21	11	<68	13	22
K50000CT	23	1.7	.3	12	<46	6	4	<68	6	12
K50900CT	180	3.0	.6	16	<46	20	11	<68	12	23
K51000CT	280	2.5	.5	17	<46	21	15	<68	14	24

Table P-1 (con.)
Complete tabulation of bulk chemical data, Kimbeto overburden rock, dry weight basis.

Sample	Sn ppm-S	Sr ppm-S	Ti%-S	V ppm-S	Y ppm-S	Yb ppm-S	Zn ppm-S	Zr ppm-S	Lab. No.
				Sandstones					
K50200SA	<4.6	520	.21	88	31	3.1	86	180	215,104
K50410SA	<4.6	240	.30	66	21	2.4	63	350	215,225
K50500SA	<4.6	280	.17	46	24	2.2	46	190	215,332
K50600SA	<4.6	330	.24	35	18	1.8	32	120	215,243
K51300SA	<4.6	270	.27	75	22	2.6	61	150	215,227
K51400SA	<4.6	230	.33	67	25	2.7	80	210	215,071
K5140XSA	<4.6	210	.44	94	27	3.4	110	180	215,251
K51800SA	5.0	76	.07	6	8	.7	<5	71	215,288
K51810SA	<4.6	240	.27	80	24	2.3	120	290	215,308
K51900SA	<4.6	200	.31	75	26	2.3	71	290	215,198
K5190XSA	<4.6	200	.22	72	21	1.9	70	180	215,235
K52200SA	<4.6	150	.27	64	29	2.4	92	330	215,297
K5220XSA	<4.6	110	.14	52	28	2.7	64	280	215,097
K92800SA	<4.6	53	.08	25	13	1.4	18	100	215,113
K93200SA	<4.6	150	.14	47	20	2.2	63	140	215,340
K50100SC	<4.6	420	.42	110	48	4.8	87	700	215,087
K5010XSC	<4.6	360	.33	88	35	4.5	93	460	215,121
K50800SC	<4.6	300	.33	95	31	3.7	100	260	215,208
K51700SC	<4.6	230	.30	98	27	2.6	81	220	215,199
K52100SC	<4.6	180	.28	92	37	3.1	85	400	215,248
K52900SC	<4.6	120	.28	64	31	3.7	57	330	215,055
K92100SC	<4.6	290	.40	61	29	3.3	51	340	215,165
K92500SC	<4.6	210	.36	72	36	3.3	47	220	215,167
K93600SC	<4.6	170	.18	56	23	2.4	64	260	215,108
K94100SC	<4.6	250	.23	58	37	3.6	110	200	215,068
K50300ST	<4.6	370	.28	45	28	3.0	53	300	215,238
K50700ST	<4.6	320	.48	89	43	4.3	85	590	215,274
				Siltstones					
K51600TA	<4.6	280	.37	75	40	3.7	94	270	215,060
K50310TC	<4.6	370	.46	75	36	4.3	86	540	215,245
K51100TC	<4.6	230	.46	100	34	3.1	88	240	215,182
K51110TC	<4.6	200	.25	76	36	3.4	77	230	215,335
				Claystones					
K52300CA	<4.6	170	.39	110	29	2.6	76	320	215,268
K52310CA	<4.6	160	.23	77	31	3.1	76	230	215,229
K50000CT	<4.6	260	.08	49	31	3.1	34	160	215,111
K50900CT	<4.6	200	.29	86	39	3.7	110	210	215,218
K51000CT	<4.6	220	.27	99	33	3.6	82	210	215,123

Table P-1 (con.)
Complete tabulation of bulk chemical data, Kimbeto overburden rock, dry weight basis--continued

Sample	Latitude	Longitude	SiO2%	Al2O3%	T-Fe2O3%	MgO%	CaO%	Na2O%	K2O%	TiO2%	P2O5%
					Claystones--continued						
K51500CT	36 9 17	107 54 4	65.1	15.8	6.4	1.40	.7	1.5	3.0	.69	<.1
K52000CT	36 9 17	107 54 4	60.8	15.8	5.0	1.20	.7	1.4	2.3	.63	<.1
K5200XCT	36 9 17	107 54 4	61.5	15.9	5.1	1.20	.6	1.4	2.3	.64	<.1
K90000CT	36 7 22	107 49 46	62.4	17.3	4.9	1.40	.9	1.3	3.3	.72	.2
K90400CT	36 7 22	107 49 46	65.3	15.5	5.5	1.30	.8	1.6	2.9	.65	<.1
K9040XCT	36 7 22	107 49 46	64.8	15.4	5.5	1.30	.8	1.5	2.9	.64	<.1
K90800CT	36 7 22	107 49 46	60.1	20.4	5.1	1.40	.6	1.9	2.0	.65	<.1
K91210CT	36 7 22	107 49 46	64.5	16.6	5.2	1.40	.5	1.7	3.4	.67	<.1
K91600CT	36 7 22	107 49 46	67.1	16.0	4.1	1.30	.4	1.2	2.4	.63	<.1
K9160XCT	36 7 22	107 49 46	67.1	15.9	4.1	1.40	.4	1.2	2.3	.63	<.1

Table P-1 (con.)
Complete tabulation of bulk chemical data, Kimbeto overburden rock, dry weight basis--continued

Sample	MnO%	LOI%	Al%-S	B ppm-S	Ba ppm-S	Be ppm-S	Ca%-S	Ce ppm-S	Co ppm-S	Cr ppm-S	Cu ppm-S
					Claystones--continued						
K51500CT	<.02	5.4	11.0	31	490	3.8	.8	110	9	36	39
K52000CT	<.02	11.2	7.7	22	460	2.6	.7	80	6	31	40
K5200XCT	<.02	10.5	9.0	32	500	3.7	.7	95	7	38	48
K90000CT	<.02	7.1	8.3	16	540	2.7	.8	110	17	29	46
K90400CT	<.02	5.8	6.8	14	450	2.9	.6	130	37	32	34
K9040XCT	<.02	5.8	12.0	30	580	4.2	1.0	140	68	39	50
K90800CT	<.02	7.5	8.4	14	470	2.9	.6	110	12	23	27
K91210CT	<.02	5.2	9.0	26	510	2.5	.6	140	42	31	39
K91600CT	<.02	6.6	8.0	23	480	2.2	.5	81	4	37	49
K9160XCT	<.02	6.7	6.0	13	400	1.9	.4	67	4	30	47

Table P-1 (con.)
Complete tabulation of bulk chemical data, Kimbeto overburden rock, dry weight basis--continued

Sample	Dy ppm-S	Er ppm-S	Eu ppm-S	Fe%-S	Ga ppm-S	Gd ppm-S	Ge ppm-S	K%-S	La ppm-S	Li ppm-S	Mg%-S
					Claystones--continued						
K51500CT	<10	5.6	1.3	4.7	24	14	1.6	3.2	49	<100	.85
K52000CT	<10	<4.6	<1.0	2.7	21	<10	2.7	2.6	34	<100	.62
K5200XCT	<10	<4.6	<1.0	3.6	17	<10	2.5	1.9	44	<100	.72
K90000CT	<10	<4.6	<1.0	2.9	18	<10	1.4	3.1	53	<100	.83
K90400CT	<10	<4.6	<1.0	2.9	14	<10	1.4	2.9	50	<100	.66
K9040XCT	<10	<4.6	1.5	5.1	26	13	2.2	3.4	62	<100	.89
K90800CT	<10	<4.6	<1.0	2.3	17	17	1.4	1.5	45	110	.63
K91210CT	<10	<4.6	1.2	4.0	26	12	1.4	3.3	65	<100	.78
K91600CT	<10	<4.6	<1.0	2.7	20	18	1.7	2.6	34	<100	.76
K9160XCT	<10	<4.6	<1.0	1.9	13	<10	<1.0	2.2	27	<100	.66

Table P-1 (con.)
Complete tabulation of bulk chemical data, Kimbeto overburden rock, dry weight basis--continued

Sample	Mn ppm-S	Mo ppm-S	Na%-S	Nb ppm-S	Nd ppm-S	Ni ppm-S	Pb ppm-S	Pr ppm-S	Sc ppm-S	Si%-S
					Claystones--continued					
K51500CT	220	4.6	.8	21	<46	25	22	<68	15	36
K52000CT	110	2.7	.7	18	<46	14	16	<68	13	29
K5200XCT	82	3.6	.7	18	<46	19	15	<68	15	33
K90000CT	220	3.2	.7	23	<46	29	22	<68	12	25
K90400CT	62	3.6	.7	18	53	43	18	<68	15	25
K9040XCT	200	1.7	.8	24	47	62	31	<68	18	>37
K90800CT	59	3.0	.8	18	<46	21	18	<68	13	21
K91210CT	170	3.3	.9	23	<46	57	25	<68	16	33
K91600CT	81	3.5	.5	21	<46	14	20	<68	14	31
K9160XCT	42	2.1	.5	22	<46	12	11	<68	14	23

Table P-1 (con.)
Complete tabulation of bulk chemical data, Kimbeto overburden rock, dry weight basis--continued

Sample	Sn ppm-S	Sr ppm-S	Ti%-S	V ppm-S	Y ppm-S	Yb ppm-S	Zn ppm-S	Zr ppm-S	Lab. No.
				Claystones--continued					
K51500CT	<4.6	280	.59	120	37	4.3	100	380	215,159
K52000CT	<4.6	240	.32	82	24	3.2	99	270	215,147
K5200XCT	<4.6	250	.40	98	27	2.7	110	260	215,276
K90000CT	<4.6	240	.36	98	44	4.6	94	380	215,214
K90400CT	<4.6	280	.32	94	35	3.5	67	230	215,069
K9040XCT	<4.6	280	.76	130	52	4.9	89	410	215,154
K90800CT	<4.6	260	.27	65	26	2.8	110	280	215,062
K91210CT	<4.6	200	.48	120	53	5.1	84	360	215,136
K91600CT	<4.6	230	.39	100	25	3.1	59	320	215,246
K9160XCT	<4.6	220	.23	96	27	3.1	62	340	215,095

Table P-2

Bulk chemical composition of overburden rocks at Kimbeto and other sites where coal is overlain by Cretaceous rocks; also soils and mine spoil material from the San Juan Basin

[Values are geometric means except SiO_2 values are arithmetic means. Sand indicates sandstone; Silt indicates siltstone; and clay indicates shale and other very fine-grained rock, as used in the text. If the element was below the detection limit for some samples, Cohen's technique was used to estimate the probable average.]

	Kimbeto, New Mex.				Ojo Encino, New Mex.				Other sites with Cretaceous overburden [1]				San Juan Basin Soils & Mine Spoil [2]		San Juan Basin Soils [3]	
	Sand n=27	Silt n=4	Clay n=15	Total n=46	Sand n=26	Silt n=1	Clay n=4	Total n=31	Sand n=110	Silt n=25	Clay n=77	Total n=212	Topsoil n=12	Spoil n=12	A horiz. n=30	C horiz. n=30
SiO_2%	70	70	63	68	68	70	65	68	79.3	67.3	59.8	71.1	75	64	73	73
Al_2O_3%	13.2	15.0	16.4	14.3	13.4	15.8	16.3	13.8	6.1	10.4	13.7	8.7	4.9	11.5	8.3	8.3
CaO%	1.4	0.78	0.81	1.1	1.3	0.5	0.55	1.1	0.56	1.7	1.4	0.91	1.8	2.0	0.9	1.4
Na_2O%	1.8	1.8	1.3	1.5	1.5	1.6	1.3	1.5	0.13	0.27	0.20	0.16	1.4	2.0	1.3	1.3
K_2O%	2.1	2.6	2.7	2.3	2.3	2.1	2.6	2.3	1.5	2.0	2.1	1.7	1.8	1.2	2.5	2.5
B ppm	13	18	19	15	12	11	24	14	14	23	28	19	7	13	16	11
Co ppm	8	10	12	9	8	11	11	8	4	8	9.3	5.8	6	8.5	5	4
Cr ppm	19	30	30	22	12	22	35	14	16	36	43	25	22	14	20	13
Cu ppm	14	37	39	21	10	26	37	12	7	22	30	13	10	18	8.8	6.3
Mo ppm	2.3	3.4	2.8	2.5	2.2	1.7	3.7	2.3	1.8	2.1	2.3	2.0	1.8	2.7	1.0	2.9
Pb ppm	10	19	16	12	10	10	19	11	5.8	9	13	8	11	11	11	10
V ppm	60	80	92	71	51	73	93	56	37	79	91	56	45	56	28	28
Zn ppm	61	86	80	69	55	64	94	59	35	85	105	58	41	56	31	26

[1] Danforth Hills, northwest Colorado; Corral Canyon, southeast central Wyoming; Henry Mountains and Emery, Utah

[2] Unpublished data of Severson and Gough, Table 6

[3] Unpublished data of Severson and Gough, Table 4

Table P-3.--Dispersion of data on bulk chemical composition of overburden rocks at Kimbeto and other sites where coal is overlain by Cretaceous rocks; also soils and mine spoil material from the San Juan Basin

[Values are geometric deviations (except for SiO_2 for which the values are standard deviations). Sand indicates sandstone, Silt indicates siltstone, Clay indicates shale and other very fine grained rocks, as used in the text "n" indicates number of samples analyzed.]

	Kimbeto, New Mex.				Ojo Encino, New Mex.				Other sites with Cretaceous overburden †				San Juan Basin Soils & Mine Spoil*		San Juan Basin Soils **	
	Sand n=27	Silt n=4	Clay n=15	Total n=46	Sand n=26	Silt n=1	Clay n=4	Total n=31	Sand n=110	Silt n=25	Clay n=77	Total n=212	Topsoil n=12	Spoil n=12	A horiz. n=30	C horiz. n=30
SiO_2%	7.0	5.1	4.6	7.0	8.3	--	2.5	7.7	12.1	11.5	10.4	14.8	1.1	1.1	1.1	1.0
Al_2C_3%	1.4	1.1	1.0	1.3	1.2	--	1.0	1.2	1.6	1.3	1.3	1.8	1.1	1.1	1.1	1.2
CaO%	3.8	2.2	1.9	3.1	5.9	--	1.2	5.2	8.6	3.9	3.8	6.3	1.3	1.2	1.3	1.7
Na_2O%	1.7	1.2	1.2	1.5	2.0	--	1.1	1.9	2.8	2.5	3.0	2.9	1.0	1.2	1.2	1.3
K_2O%	1.3	1.5	1.3	1.3	1.3	--	1.0	1.3	1.5	1.2	1.5	1.5	1.1	1.1	1.1	1.2
B ppm	1.4	1.2	1.4	1.5	1.6	--	1.2	1.6	1.6	1.4	1.6	1.7	1.8	1.5	1.4	1.8
Co ppm	1.5	1.6	1.3	1.9	1.4	--	1.6	1.6	2.1	1.4	1.7	2.1	1.1	1.2	1.3	1.4
Cr ppm	1.6	1.3	1.5	1.6	2.0	--	1.1	2.1	2.0	1.3	1.7	2.1	1.4	1.3	1.5	1.5
Cu ppm	2.1	1.2	1.2	2.2	2.1	--	1.0	2.3	2.8	1.6	1.6	2.9	1.5	1.6	1.4	1.7
Mo ppm	1.4	1.3	1.3	1.4	1.5	--	1.2	1.5	1.5	1.4	1.6	1.5	1.3	1.1	1.2	1.8
Pb ppm	1.5	1.7	1.6	1.7	1.4	--	1.3	1.5	1.7	1.5	6	1.9	1.2	1.2	1.2	1.3
V ppm	1.8	1.2	1.3	1.7	1.5	--	1.2	1.5	2.1	1.2	1.4	2.1	1.1	1.3	1.2	1.4
Zn ppm	2.2	1.1	1.4	1.7	1.4	--	1.3	1.5	2.2	1.3	1.4	2.3	1.1	1.5	1.2	1.4

* Unpublished data of Severson and Gough, Table 6

** Unpublished data of Severson and Gough, Table 4

† Danforth Hills, northwest Colorado; Corral Canyon, southeast central Wyoming; Henry Mountains and Emery, Utah

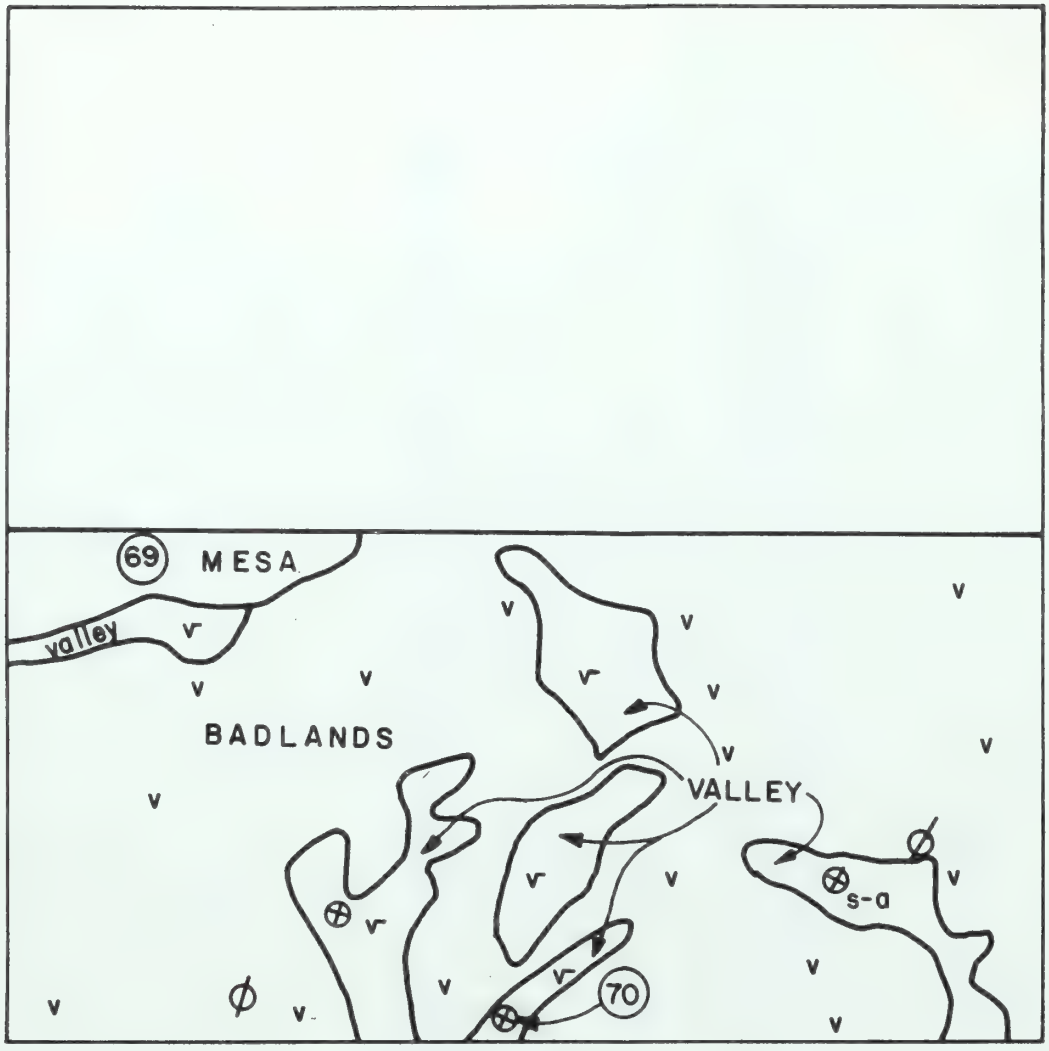
SECTION Q

LAND AND OVERBURDEN APPENDIX

Major Land Categories

Table Q-1
Acreages of Major Land Categories

T 22 N	R 11 W										R 10 W												R 9 W		Total
Sections	12	4	5	6	7	8	9	10	11	13	14	15	16	17	18	19	22	23	24	25	26	27	19	30	Acres
	Acres																								
Badlands	557	565	558	265	520	573	455	34	5	18	359	27	137	46		181	52		107	120	64		240	143	5,026
Mesas	32		12	16			182	34	120	1	135	76	239	477	188	82	339	300	331	9	245	115	36	83	3,052
Valley																									
Sandy (V)	15	62	45	33	53	30				21	131	134			29	18	75	99	78	19		33	17	159	1,051
Saline - sodic (s-a)	36	13	25	6	67	37	3	11		53	1	141	184	117	423	39	3	14	16	492	11		27	255	1,974
Miscellaneous																									
Stream channel								11		13		63	48				55	74	30						294
Active dunes									13			84													97
Hummocky								70	22	54	15	115	32				116	153	78			12			666
Total																									
Acres	640	640	640	320	640	640	640	160	160	160	640	640	640	640	640	320	640	640	640	640	320	160	320	640	12,160



1000 500 0 1000 2000

SCALE IN FEET

Mapping Symbols

- Hummocks
- Blowout
- Clay spot
- Gravelly spot
- Gumbo, Slick or scaby spot (sodic)
- V – Rock Outcrop (includes shale and sandstone)
- V. – Baked rock (scoria)
- # – Greasewood
- ③ – Profiles
- ⊗ – Check holes
- ------ Separates valley subcategories
- —— Separates land categories

MAJOR LAND CATEGORIES

	acres
MESA	16
BADLANDS	265
VALLEY	
sandy	33
s-a saline sodic	6
MISCELLANEOUS	
Active Dunes	
Hummocky	
Stream Channel	
TOTAL	320

SECTION 6

EMRIA REPORT NO. 17-77

FIGURE Q-1

1000 500 0 1000 2000

SCALE IN FEET

Mapping Symbols

- Hummocks
- Blowout
- Clay spot
- Gravelly spot
- Gumbo, Slick or scaby spot (sodic)
- V – Rock Outcrop (includes shale and sandstone)
- V. – Baked rock (scoria)
- # – Greasewood
- (3) – Profiles
- (X) – Check holes
- ------ Separates valley subcategories
- —— Separates land categories

MAJOR LAND CATEGORIES

	acres
MESA	12
BADLANDS	558
VALLEY	
sandy	45
s-a saline sodic	25
MISCELLANEOUS	
Active Dunes	
Hummocky	
Stream Channel	
TOTAL	640

SECTION 5

EMRIA REPORT NO. 17-77

FIGURE Q-2

1000 500 0 1000 2000

SCALE IN FEET

Mapping Symbols

- Hummocks
- Blowout
- Clay spot
- Gravelly spot
- Gumbo, Slick or scaby spot (sodic)
- V – Rock Outcrop (includes shale and sandstone)
- V. – Baked rock (scoria)
- # – Greasewood
- ③ – Profiles
- ⊗ – Check holes
- ------ Separates valley subcategories
- ——— Separates land categories

MAJOR LAND CATEGORIES

	acres
MESA	
BADLANDS	565
VALLEY	
sandy	62
s-a saline sodic	13
MISCELLANEOUS	
Active Dunes	
Hummocky	
Stream Channel	
TOTAL	640

SECTION 4

EMRIA REPORT NO. 17-77

FIGURE Q-3

1000 500 0 1000 2000

SCALE IN FEET

Mapping Symbols

- Hummocks
- Blowout
- Clay spot
- Gravelly spot
- Gumbo, Slick or scaby spot (sodic)
- V – Rock Outcrop (includes shale and sandstone)
- V. – Baked rock (scoria)
- # – Greasewood
- (3) – Profiles
- ⊗ – Check holes
- ------ Separates valley subcategories
- —— Separates land categories

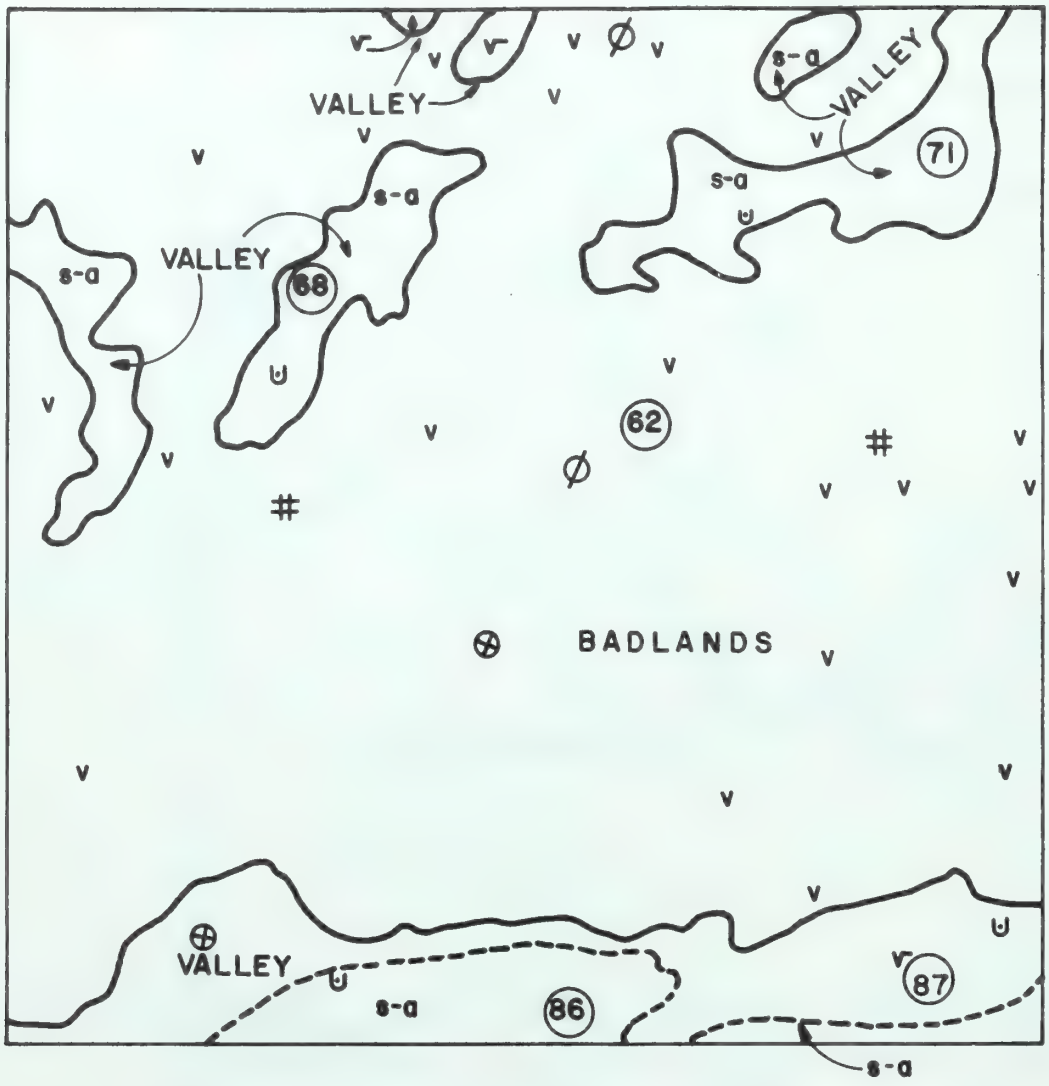
MAJOR LAND CATEGORIES

	acres
MESA	32
BADLANDS	557
VALLEY	
sandy	15
s-a saline sodic	36
MISCELLANEOUS	
Active Dunes	
Hummocky	
Stream Channel	
TOTAL	640

SECTION 12

EMRIA REPORT NO. 17-77

FIGURE Q-4



1000 500 0 1000 2000

SCALE IN FEET

Mapping Symbols

- Hummocks
- ⊍ – Blowout
- Clay spot
- Gravelly spot
- Gumbo, Slick or scaby spot (sodic)
- V – Rock Outcrop (includes shale and sandstone)
- V. – Baked rock (scoria)
- # – Greasewood
- ③ – Profiles
- ⊗ – Check holes
- ------ Separates valley subcategories
- —— Separates land categories

MAJOR LAND CATEGORIES

	acres
MESA	
BADLANDS	520
VALLEY	
sandy	53
s-a saline sodic	67
MISCELLANEOUS	
Active Dunes	
Hummocky	
Stream Channel	
TOTAL	640

SECTION 7

EMRIA REPORT NO. 17-77

FIGURE Q-5

1000 500 0 1000 2000

SCALE IN FEET

Mapping Symbols

- Hummocks
- Blowout
- Clay spot
- Gravelly spot
- Gumbo, Slick or scaby spot (sodic)
- V – Rock Outcrop (includes shale and sandstone)
- V. – Baked rock (scoria)
- # – Greasewood
- (3) – Profiles
- (X) – Check holes
- ------ Separates valley subcategories
- —— Separates land categories

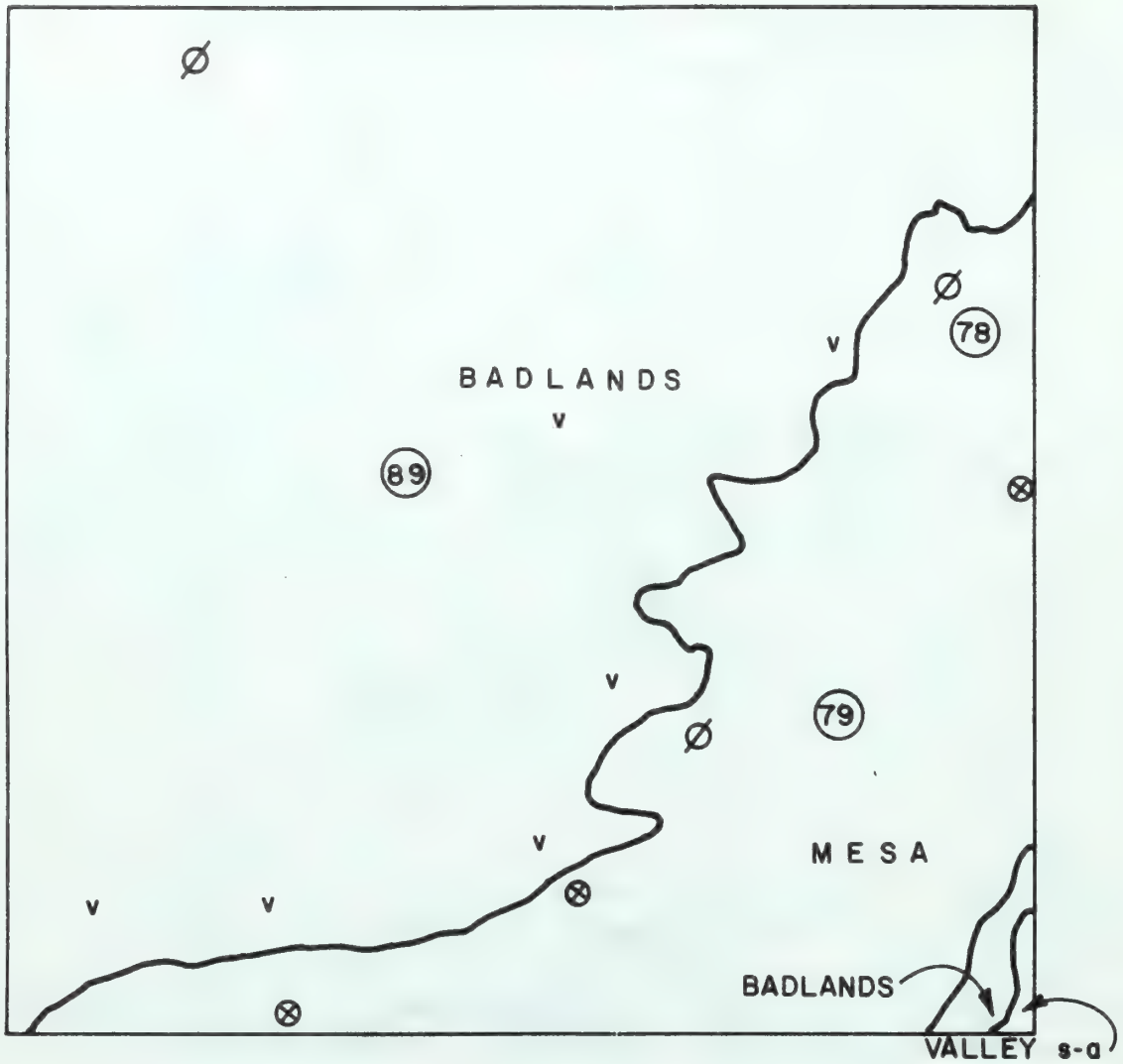
MAJOR LAND CATEGORIES

	acres
MESA	
BADLANDS	573
VALLEY	
sandy	30
s-a saline sodic	37
MISCELLANEOUS	
Active Dunes	
Hummocky	
Stream Channel	
TOTAL	640

SECTION 8

EMRIA REPORT NO. 17-77

FIGURE Q-6



1000 500 0 1000 2000

SCALE IN FEET

Mapping Symbols

- Hummocks
- Blowout
- Clay spot
- Gravelly spot
- Gumbo, Slick or scaby spot (sodic)
- V – Rock Outcrop (includes shale and sandstone)
- V. – Baked rock (scoria)
- # – Greasewood
- (3) – Profiles
- (X) – Check holes
- ------ Separates valley subcategories
- —— Separates land categories

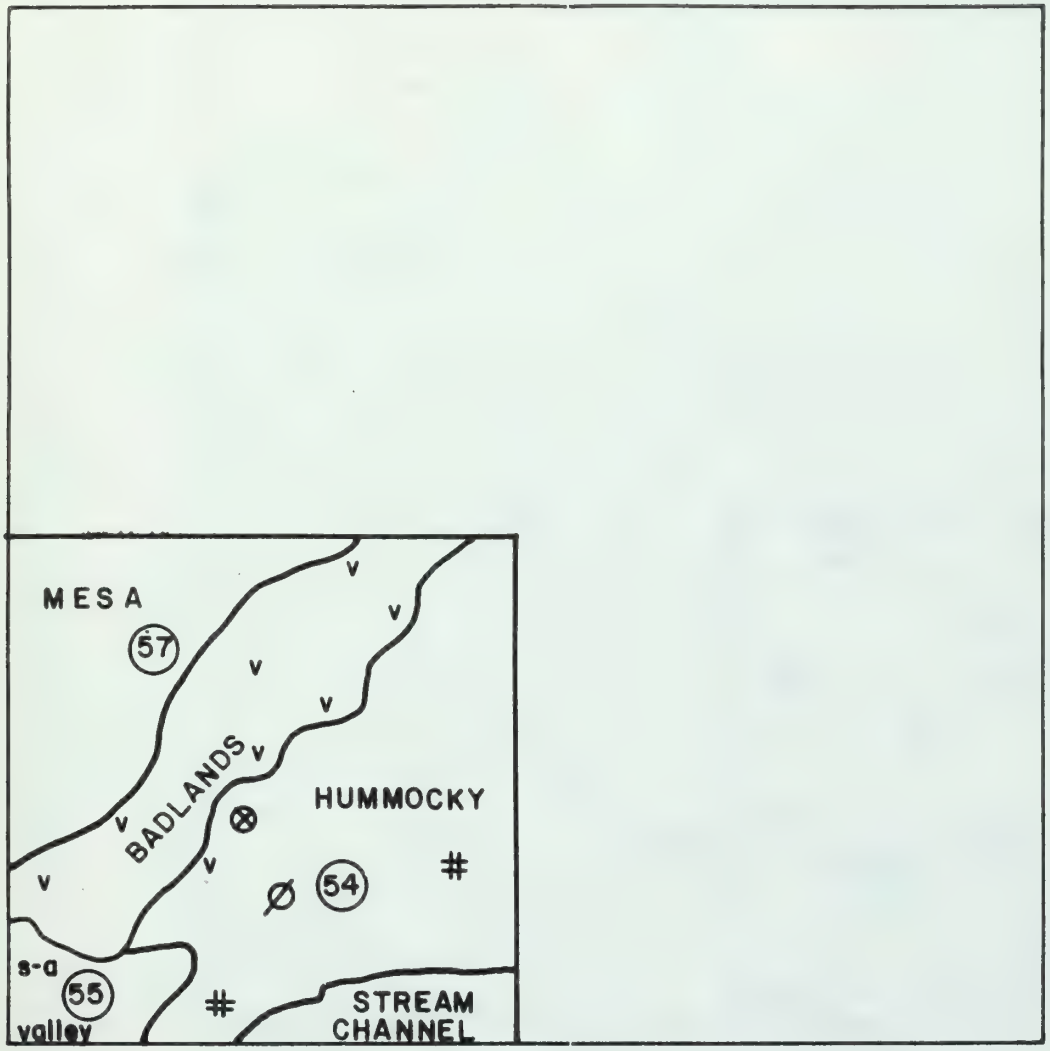
MAJOR LAND CATEGORIES

	acres
MESA	182
BADLANDS	455
VALLEY	
sandy	
s-a saline sodic	3
MISCELLANEOUS	
Active Dunes	
Hummocky	
Stream Channel	
TOTAL	640

SECTION 9

EMRIA REPORT NO. 17-77

FIGURE Q-7



1000 500 0 1000 2000

SCALE IN FEET

Mapping Symbols

- Hummocks
- Blowout
- Clay spot
- Gravelly spot
- Gumbo, Slick or scaby spot (sodic)
- V – Rock Outcrop (includes shale and sandstone)
- V. – Baked rock (scoria)
- # – Greasewood
- (3) – Profiles
- ⊗ – Check holes
- ------ Separates valley subcategories
- —— Separates land categories

MAJOR LAND CATEGORIES

	acres
MESA	34
BADLANDS	34
VALLEY	
sandy	
s-a saline sodic	11
MISCELLANEOUS	
Active Dunes	
Hummocky	70
Stream Channel	11
TOTAL	160

SECTION 10

EMRIA REPORT NO. 17-77

FIGURE Q-8

1000 500 0 1000 2000

SCALE IN FEET

Mapping Symbols

- Hummocks
- Blowout
- Clay spot
- Gravelly spot
- Gumbo, Slick or scaby spot (sodic)
- V – Rock Outcrop (includes shale and sandstone)
- Baked rock (scoria)
- # – Greasewood
- (3) – Profiles
- (⊗) – Check holes
- ------ Separates valley subcategories
- —— Separates land categories

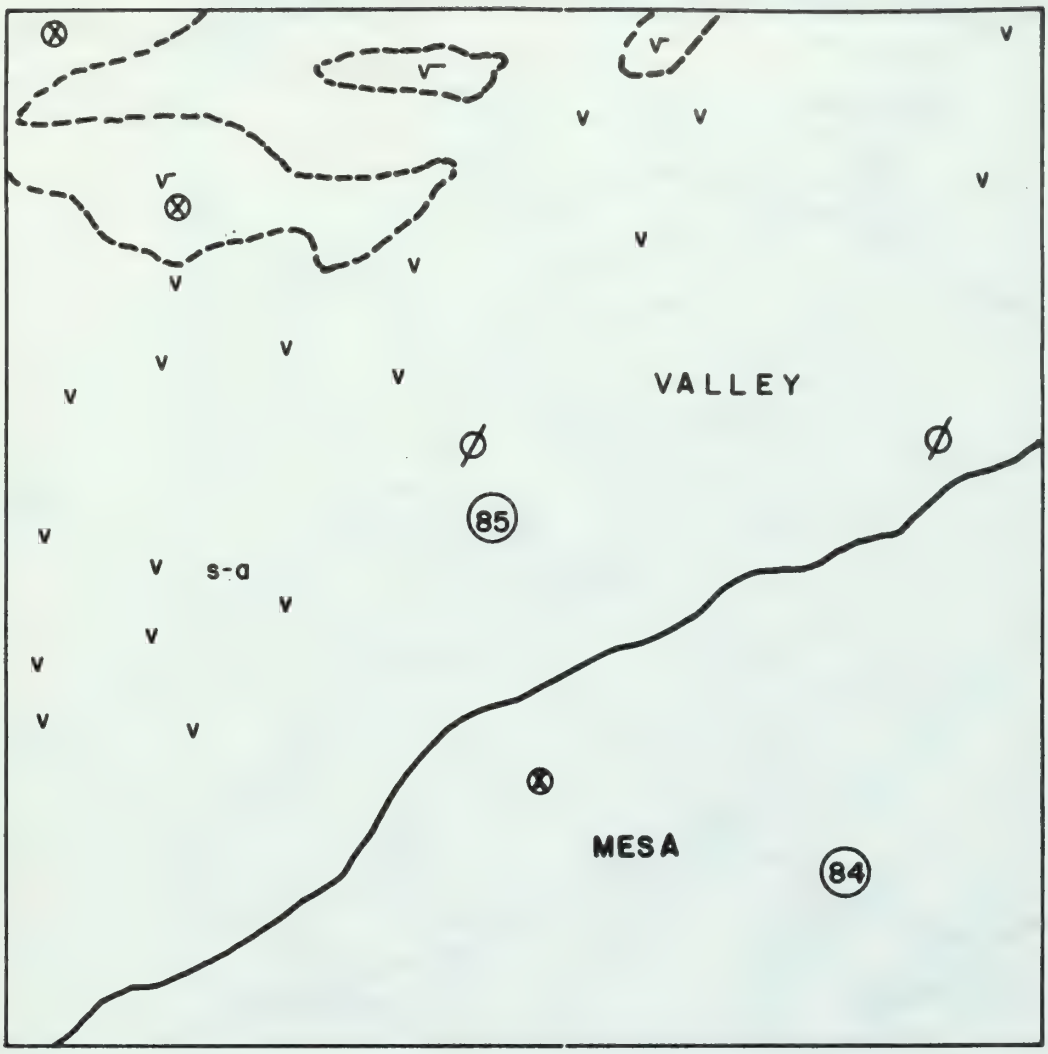
MAJOR LAND CATEGORIES

	acres
MESA	120
BADLANDS	5
VALLEY	
sandy	
s-a saline sodic	
MISCELLANEOUS	
Active Dunes	13
Hummocky	22
Stream Channel	
TOTAL	160

SECTION II

EMRIA REPORT NO. 17-77

FIGURE Q-9



1000 500 0 1000 2000

SCALE IN FEET

Mapping Symbols

- Hummocks
- Blowout
- Clay spot
- Gravelly spot
- Gumbo, Slick or scaby spot (sodic)
- V – Rock Outcrop (includes shale and sandstone)
- V. – Baked rock (scoria)
- # – Greasewood
- ③ – Profiles
- ⊗ – Check holes
- ------ Separates valley subcategories
- ——— Separates land categories

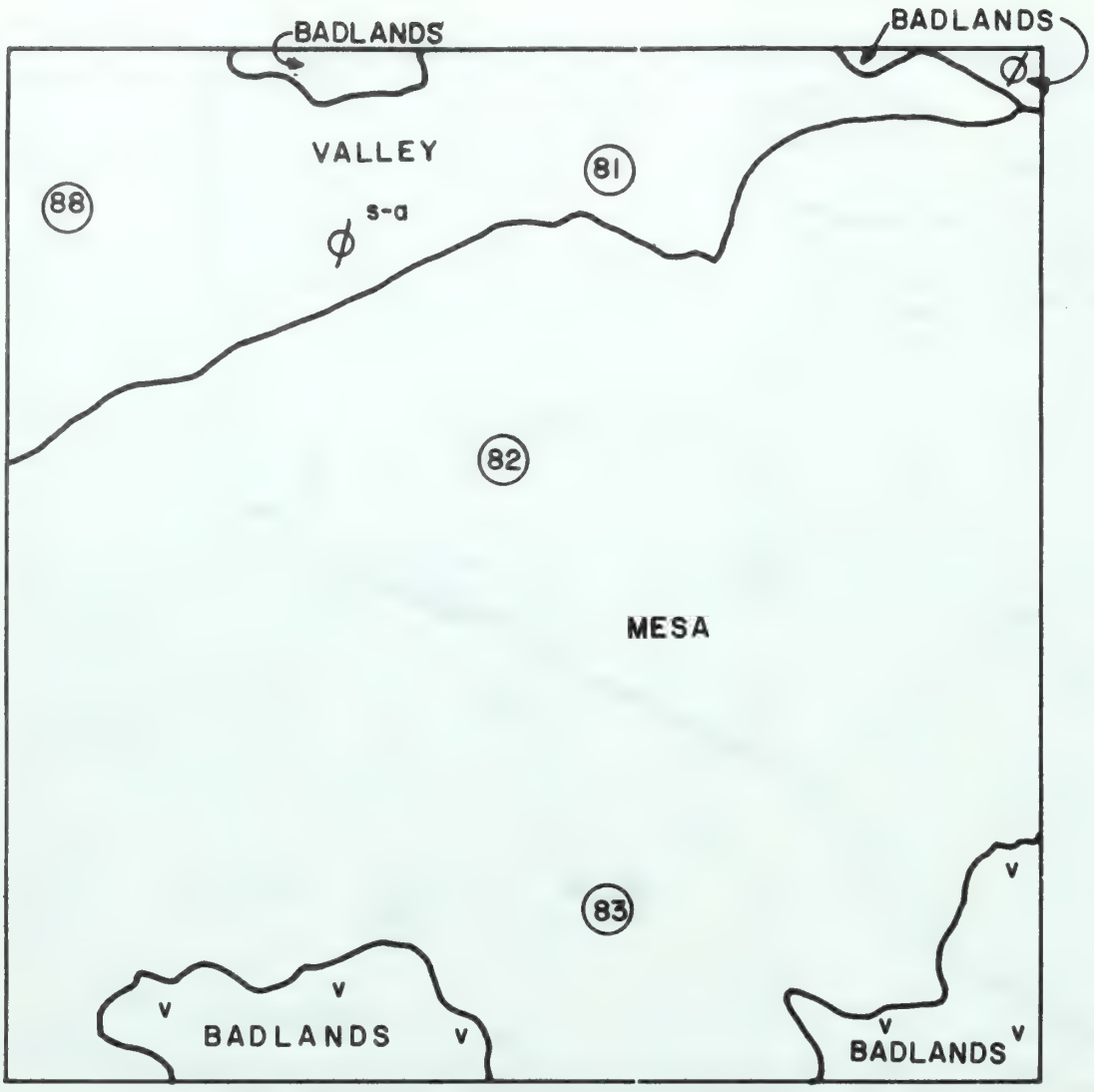
MAJOR LAND CATEGORIES

	acres
MESA	188
BADLANDS	
VALLEY	
sandy	29
s-a saline sodic	423
MISCELLANEOUS	
Active Dunes	
Hummocky	
Stream Channel	
TOTAL	640

SECTION 18

EMRIA REPORT NO. 17-77

FIGURE Q-10



1000 500 0 1000 2000

SCALE IN FEET

Mapping Symbols

- Hummocks
- Blowout
- Clay spot
- Gravelly spot
- Gumbo, Slick or scaby spot (sodic)
- V – Rock Outcrop (includes shale and sandstone)
- V. – Baked rock (scoria)
- # – Greasewood
- ③ – Profiles
- ⊗ – Check holes
- ------ Separates valley subcategories
- —— Separates land categories

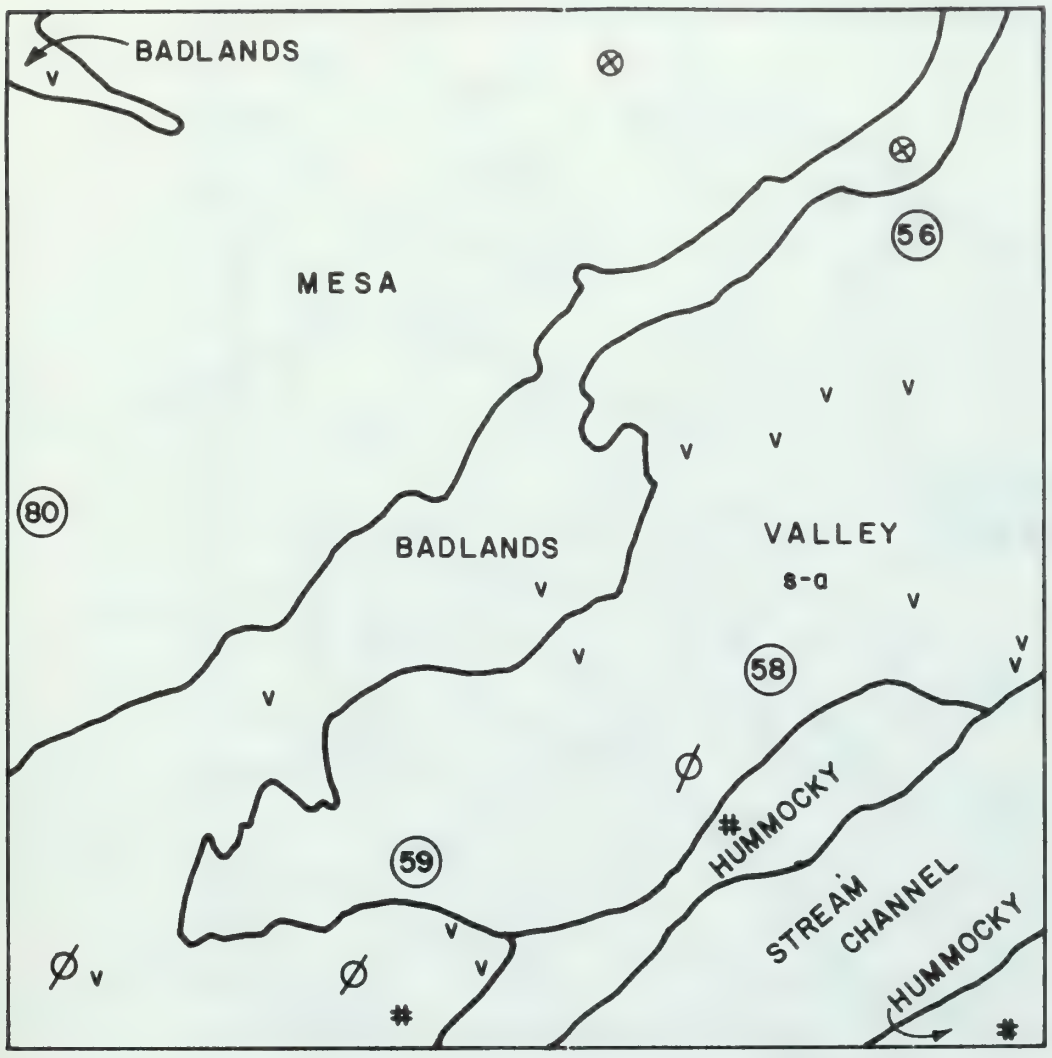
MAJOR LAND CATEGORIES

	acres
MESA	477
BADLANDS	46
VALLEY	
sandy	
s-a saline sodic	117
MISCELLANEOUS	
Active Dunes	
Hummocky	
Stream Channel	
TOTAL	640

SECTION 17

EMRIA REPORT NO. 17-77

FIGURE Q-11



1000 500 0 000 2000

SCALE IN FEET

Mapping Symbols

- Hummocks
- Blowout
- Clay spot
- Gravelly spot
- Gumbo, Slick or scaby spot (sodic)
- V – Rock Outcrop (includes shale and sandstone)
- V. – Baked rock (scoria)
- # – Greasewood
- ③ – Profiles
- ⊗ – Check holes
- ------ Separates valley subcategories
- —— Separates land categories

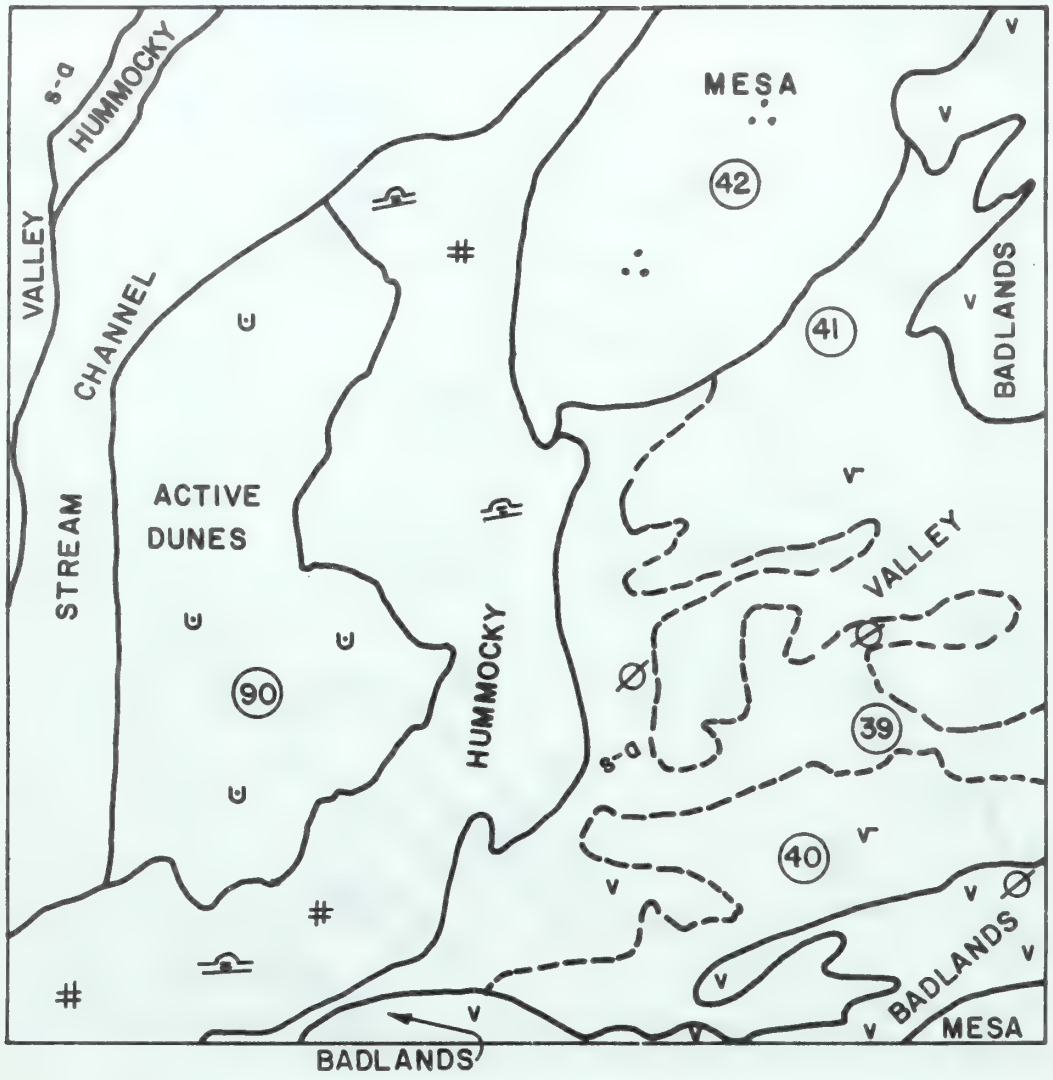
MAJOR LAND CATEGORIES

	acres
MESA	239
BADLANDS	137
VALLEY	
v sandy	
s-a saline sodic	184
MISCELLANEOUS	
Active Dunes	
Hummocky	32
Stream Channel	48
TOTAL	640

SECTION 16

EMRIA REPORT NO. 17-77

FIGURE Q-12



Mapping Symbols

- Hummocks
- Blowout
- Clay spot
- Gravelly spot
- Gumbo, Slick or scaby spot (sodic)
- V – Rock Outcrop (includes shale and sandstone)
- V. – Baked rock (scoria)
- # – Greasewood
- ③ – Profiles
- ⊗ – Check holes
- ------ Separates valley subcategories
- —— Separates land categories

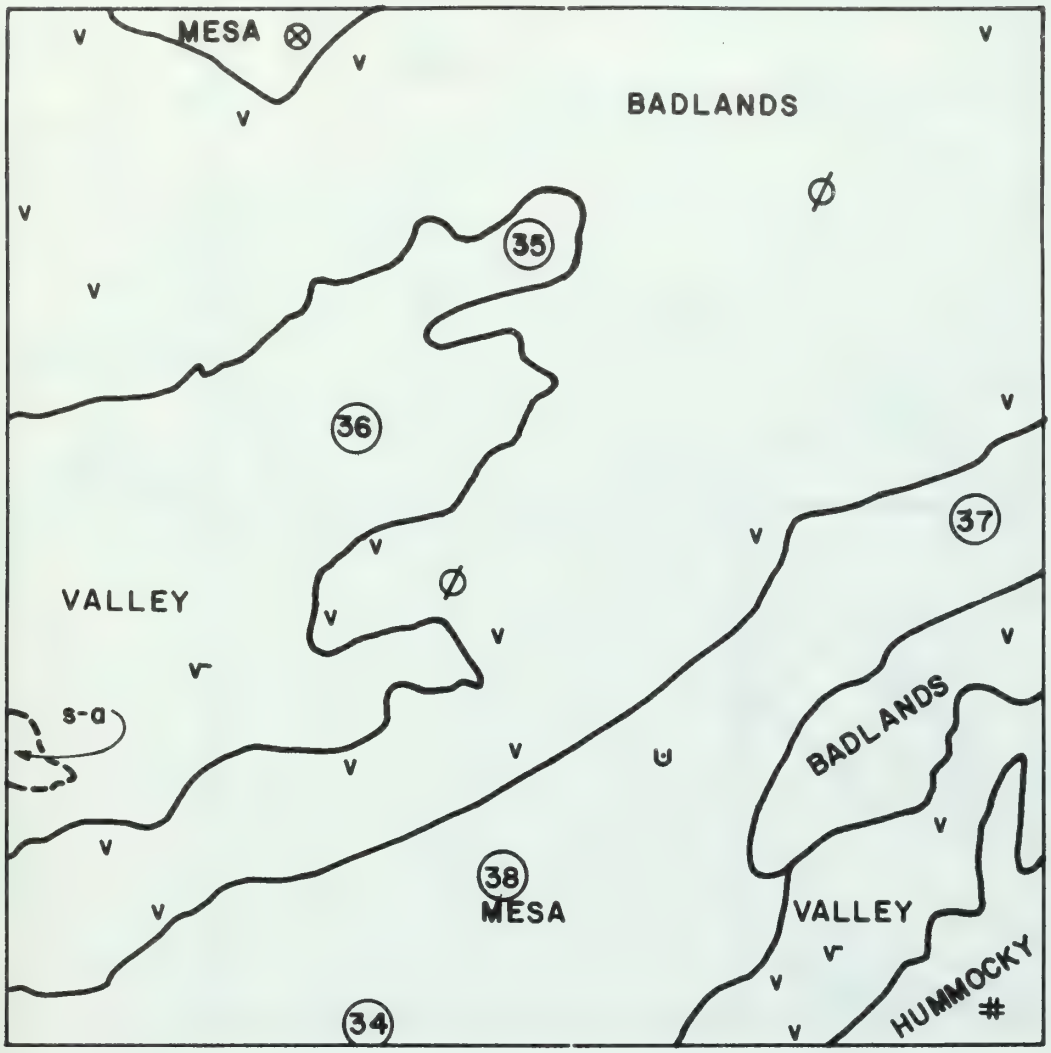
MAJOR LAND CATEGORIES

	acres
MESA	76
BADLANDS	27
VALLEY	
sandy	134
s-a saline sodic	141
MISCELLANEOUS	
Active Dunes	84
Hummocky	115
Stream Channel	63
TOTAL	640

SECTION 15

EMRIA REPORT NO. 17-77

FIGURE Q-13



1000 500 0 1000 2000

SCALE IN FEET

Mapping Symbols

- Hummocks
- Blowout
- Clay spot
- Gravelly spot
- Gumbo, Slick or scaby spot (sodic)
- V – Rock Outcrop (includes shale and sandstone)
- V. – Baked rock (scoria)
- # – Greasewood
- ③ – Profiles
- ⊗ – Check holes
- ------ Separates valley subcategories
- —— Separates land categories

MAJOR LAND CATEGORIES

	acres
MESA	135
BADLANDS	359
VALLEY	
sandy	131
s-a saline sodic	1
MISCELLANEOUS	
Active Dunes	
Hummocky	14
Stream Channel	
TOTAL	640

SECTION 14

EMRIA REPORT NO. 17-77

FIGURE Q-14

1000 500 0 1000 2000

SCALE IN FEET

Mapping Symbols

- Hummocks
- Blowout
- Clay spot
- Gravelly spot
- Gumbo, Slick or scaby spot (sodic)
- V – Rock Outcrop (includes shale and sandstone)
- V. – Baked rock (scoria)
- # – Greasewood
- ③ – Profiles
- ⊗ – Check holes
- ------ Separates valley subcategories
- —— Separates land categories

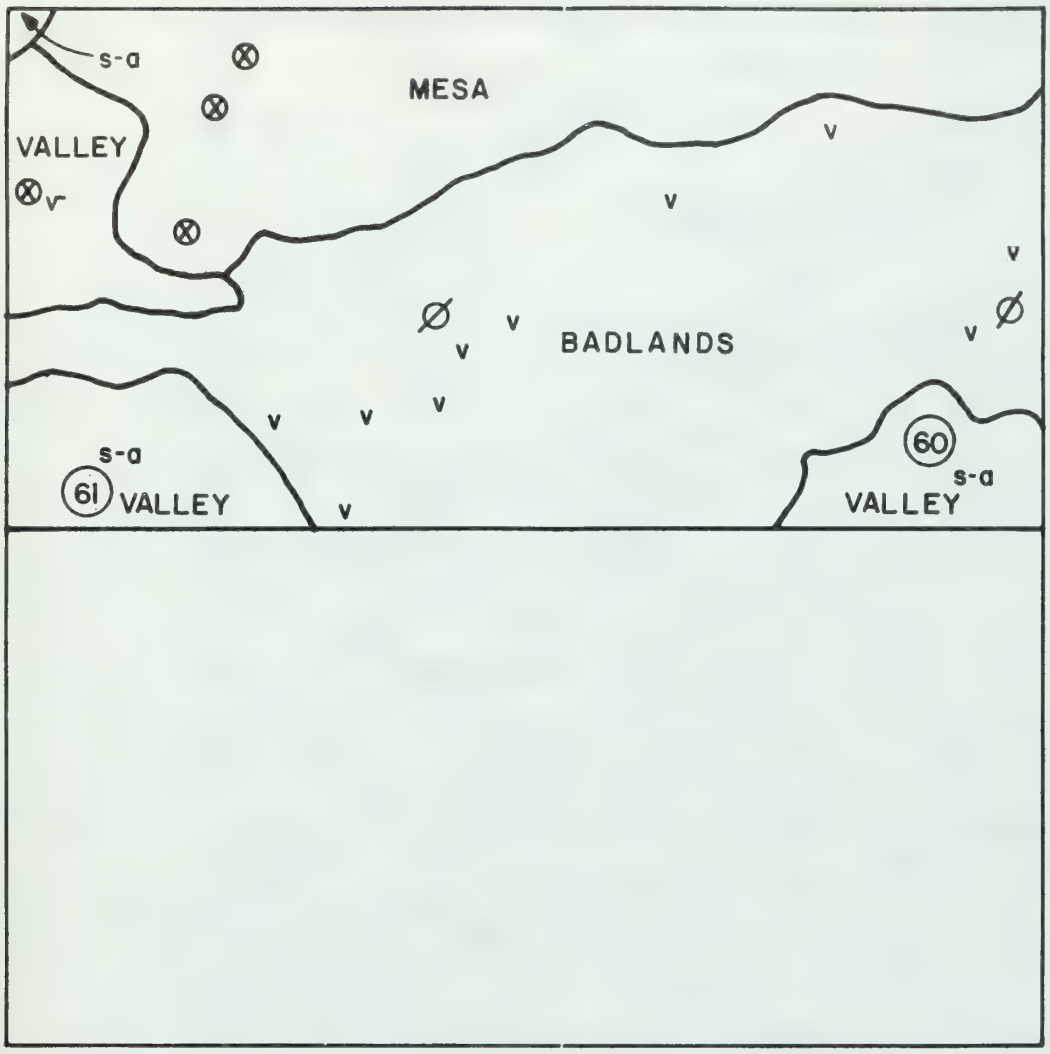
MAJOR LAND CATEGORIES

	acres
MESA	1
BADLANDS	18
VALLEY	
sandy	21
s-a saline sodic	53
MISCELLANEOUS	
Active Dunes	
Hummocky	54
Stream Channel	13
TOTAL	160

SECTION 13

EMRIA REPORT NO. 17-77

FIGURE Q-15



1000 500 0 1000 2000

SCALE IN FEET

Mapping Symbols

- Hummocks
- Blowout
- Clay spot
- Gravelly spot
- Gumbo, Slick or scaby spot (sodic)
- V – Rock Outcrop (includes shale and sandstone)
- V. – Baked rock (scoria)
- # – Greasewood
- (3) – Profiles
- (X) – Check holes
- ------ Separates valley subcategories
- ——— Separates land categories

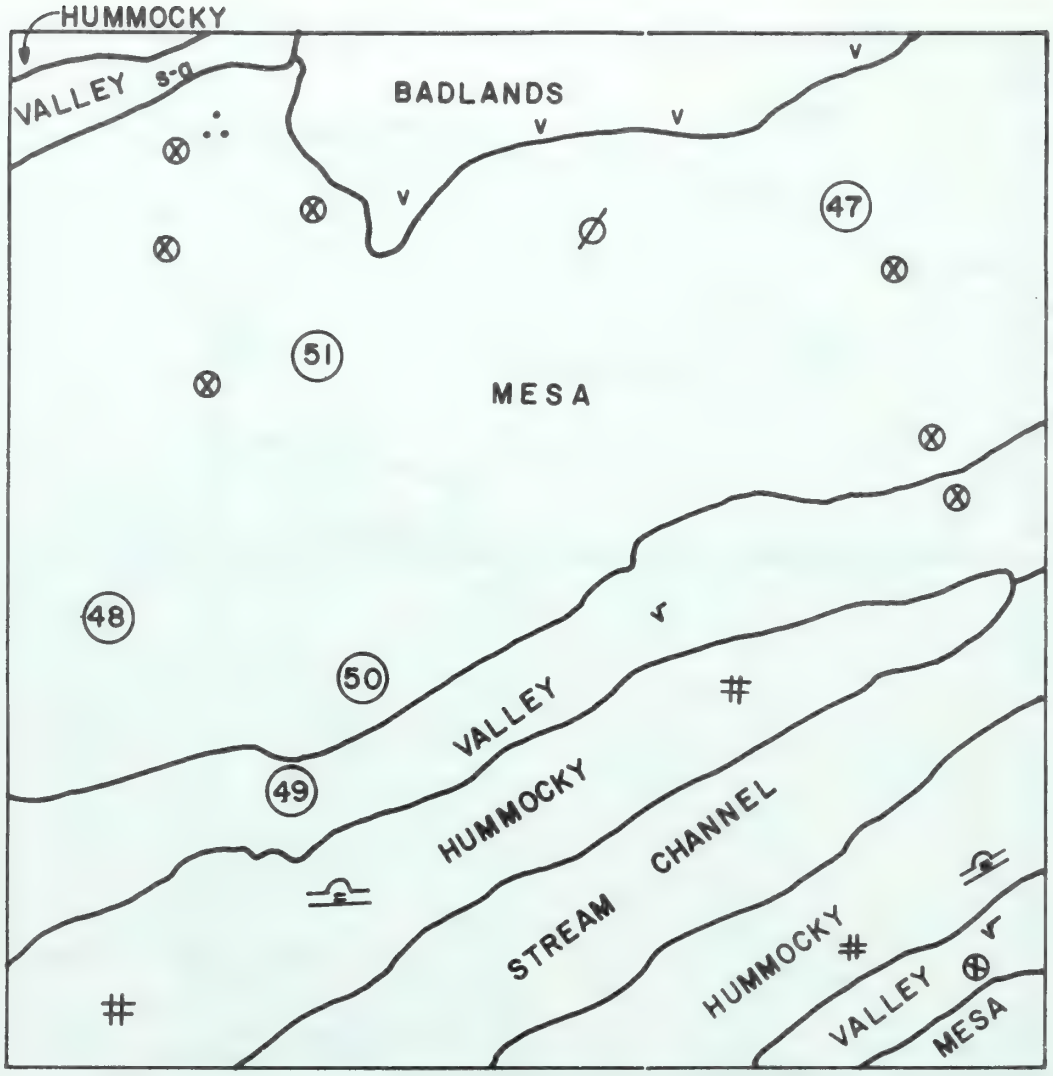
MAJOR LAND CATEGORIES

	acres
MESA	82
BADLANDS	181
VALLEY	
v⌐ sandy	18
s-a saline sodic	39
MISCELLANEOUS	
Active Dunes	
Hummocky	
Stream Channel	
TOTAL	320

SECTION 19

EMRIA REPORT NO. 17-77

FIGURE Q-16



1000 500 0 1000 2000

SCALE IN FEET

Mapping Symbols

- Hummocks
- Blowout
- Clay spot
- Gravelly spot
- Gumbo, Slick or scaby spot (sodic)
- V – Rock Outcrop (includes shale and sandstone)
- V. – Baked rock (scoria)
- # – Greasewood
- (3) – Profiles
- ⊗ – Check holes
- ------ Separates valley subcategories
- —— Separates land categories

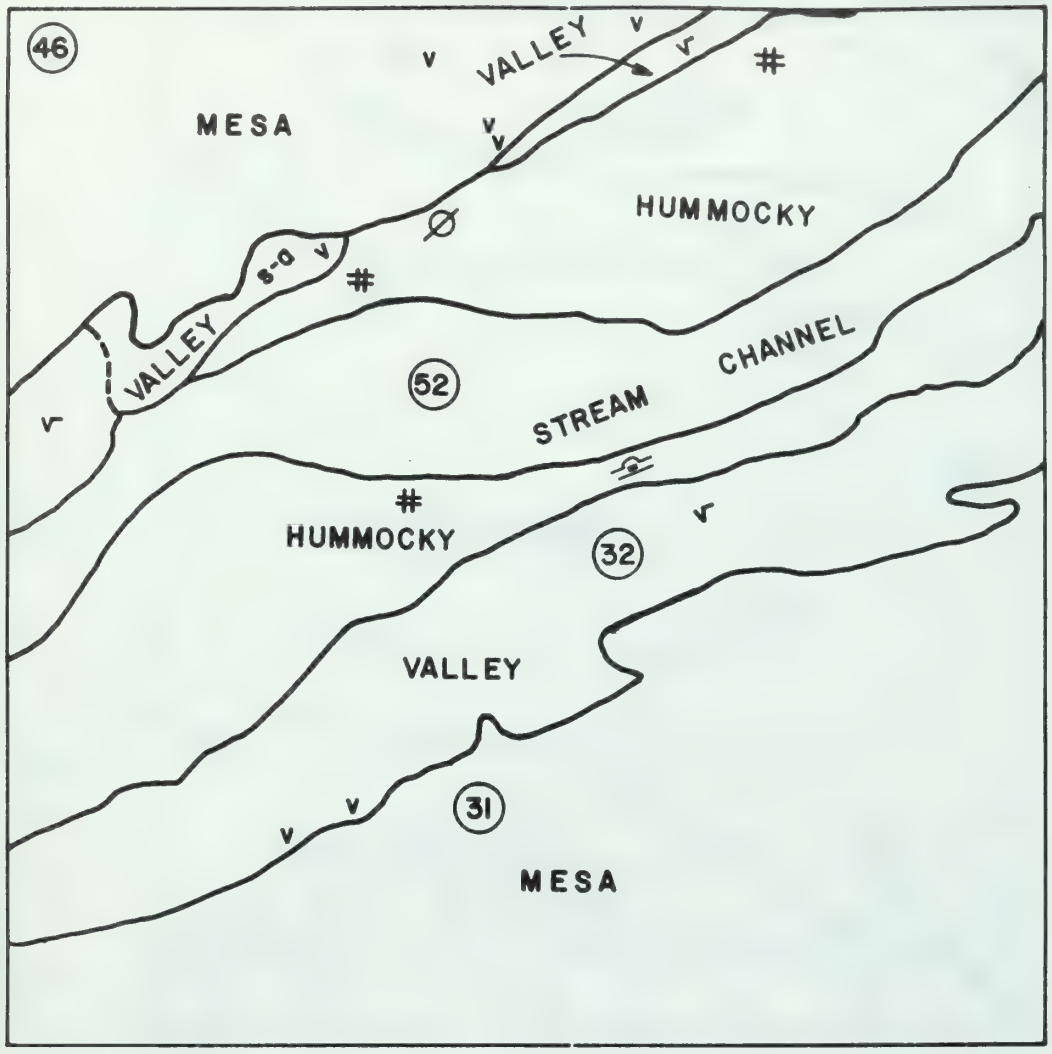
MAJOR LAND CATEGORIES

	acres
MESA	339
BADLANDS	52
VALLEY	
sandy	75
s-a saline sodic	3
MISCELLANEOUS	
Active Dunes	
Hummocky	116
Stream Channel	55
TOTAL	640

SECTION 22

EMRIA REPORT NO. 17-77

FIGURE Q-17



1000 500 0 1000 2000

SCALE IN FEET

Mapping Symbols

- Hummocks
- Blowout
- Clay spot
- Gravelly spot
- Gumbo, Slick or scaby spot (sodic)
- V – Rock Outcrop (includes shale and sandstone)
- V. – Baked rock (scoria)
- # – Greasewood
- (3) – Profiles
- (X) – Check holes
- ------ Separates valley subcategories
- —— Separates land categories

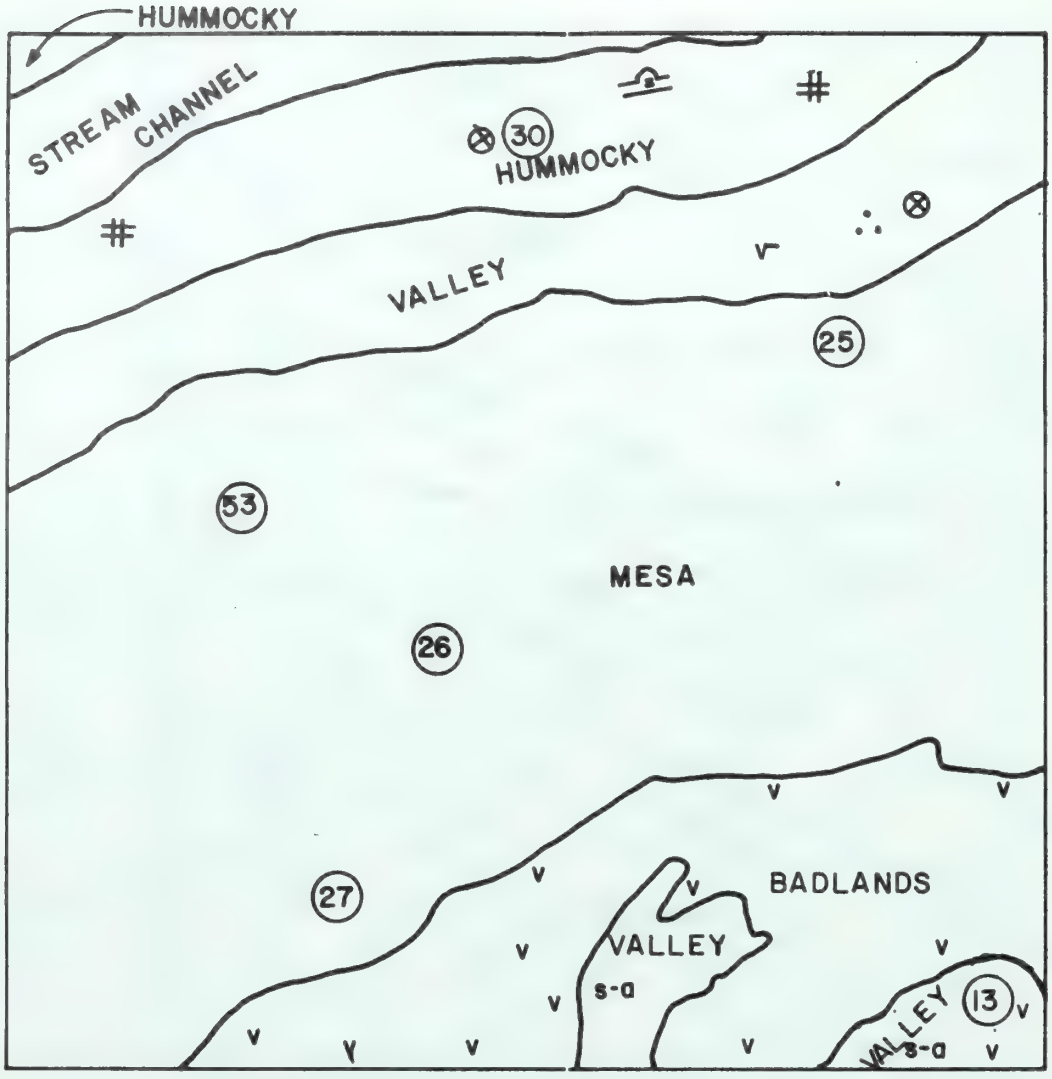
MAJOR LAND CATEGORIES

	acres
MESA	300
BADLANDS	
VALLEY	
sandy	99
s-a saline sodic	14
MISCELLANEOUS	
Active Dunes	
Hummocky	153
Stream Channel	74
TOTAL	640

SECTION 23

EMRIA REPORT NO. 17-77

FIGURE Q-18



1000 500 0 000 2000

SCALE IN FEET

Mapping Symbols

- Hummocks
- Blowout
- Clay spot
- Gravelly spot
- Gumbo, Slick or scaby spot (sodic)
- V – Rock Outcrop (includes shale and sandstone)
- V. – Baked rock (scoria)
- # – Greasewood
- (3) – Profiles
- (X) – Check holes
- ------ Separates valley subcategories
- —— Separates land categories

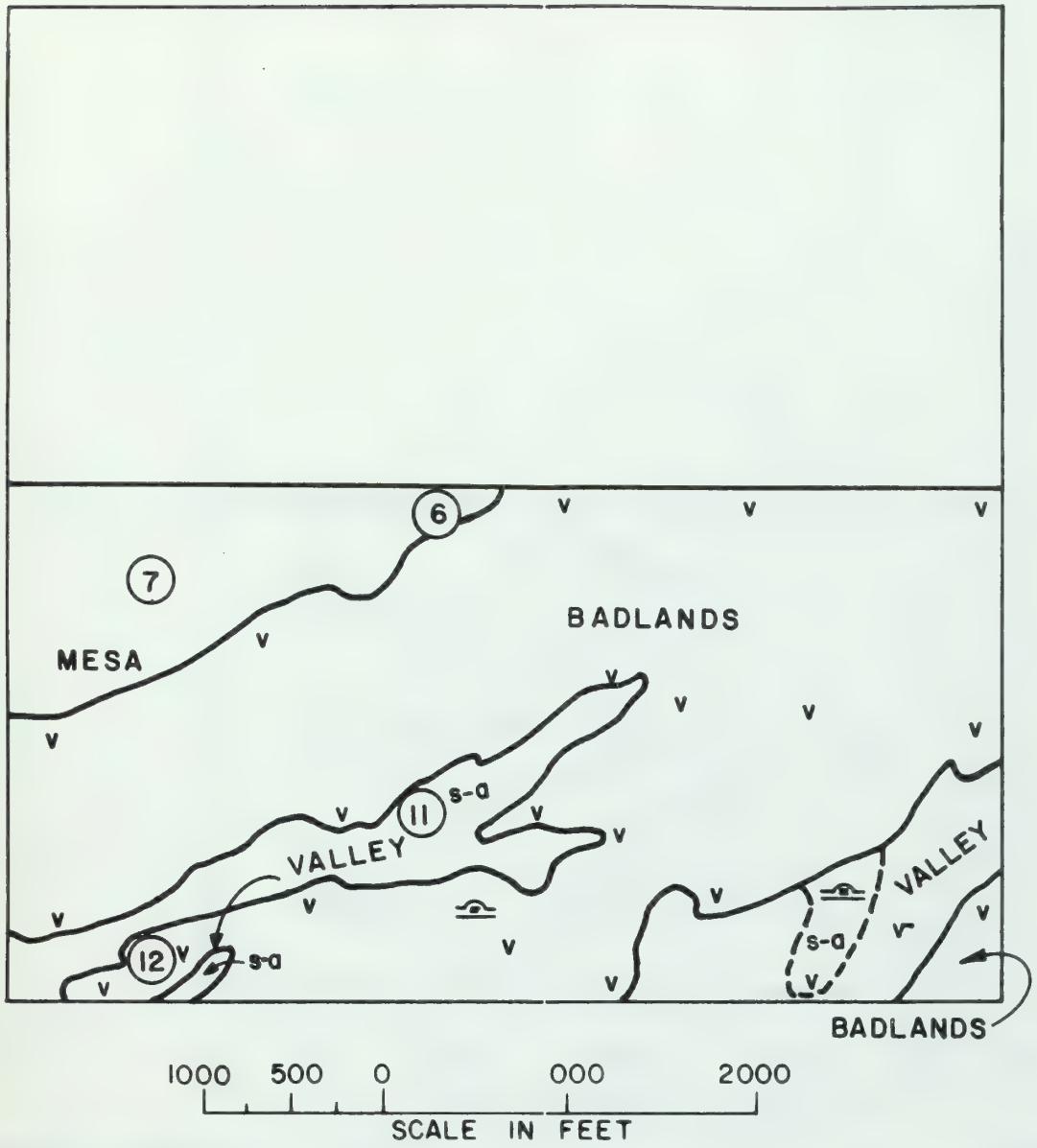
MAJOR LAND CATEGORIES

	acres
MESA	331
BADLANDS	107
VALLEY	
sandy	78
s-a saline sodic	16
MISCELLANEOUS	
Active Dunes	
Hummocky	78
Stream Channel	30
TOTAL	640

SECTION 24

EMRIA REPORT NO. 17-77

FIGURE Q-19



Mapping Symbols

- Hummocks
- Blowout
- Clay spot
- Gravelly spot
- Gumbo, Slick or scaby spot (sodic)
- V – Rock Outcrop (includes shale and sandstone)
- V. – Baked rock (scoria)
- # – Greasewood
- ③ – Profiles
- ⊗ – Check holes
- ------ Separates valley subcategories
- —— Separates land categories

MAJOR LAND CATEGORIES

	acres
MESA	36
BADLANDS	240
VALLEY	
sandy	17
s-a saline sodic	27
MISCELLANEOUS	
Active Dunes	
Hummocky	
Stream Channel	
TOTAL	320

SECTION 19

EMRIA REPORT NO. 17-77

FIGURE Q-20

1000 500 0 1000 2000

SCALE IN FEET

Mapping Symbols

- Hummocks
- Blowout
- Clay spot
- Gravelly spot
- Gumbo, Slick or scaby spot (sodic)
- V – Rock Outcrop (includes shale and sandstone)
- V. – Baked rock (scoria)
- # – Greasewood
- ③ – Profiles
- ⊗ – Check holes
- ------ Separates valley subcategories
- —— Separates land categories

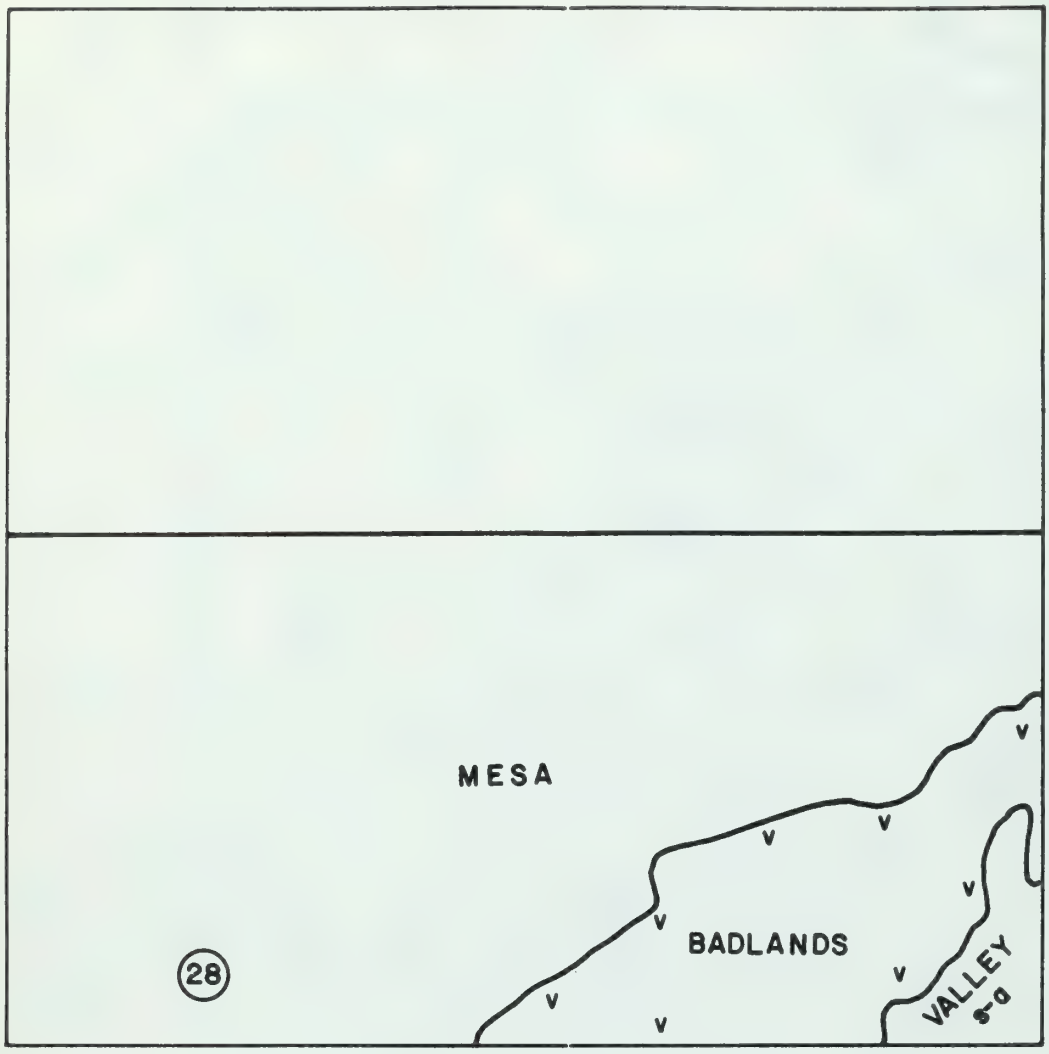
MAJOR LAND CATEGORIES

	acres
MESA	115
BADLANDS	
VALLEY	
sandy	33
s-a saline sodic	
MISCELLANEOUS	
Active Dunes	
Hummocky	12
Stream Channel	
TOTAL	160

SECTION 27

EMRIA REPORT NO. 17-77

FIGURE Q-21



Mapping Symbols

- Hummocks
- Blowout
- Clay spot
- Gravelly spot
- Gumbo, Slick or scaby spot (sodic)
- V – Rock Outcrop (includes shale and sandstone)
- V. – Baked rock (scoria)
- # – Greasewood
- ③ – Profiles
- ⊗ – Check holes
- ------ Separates valley subcategories
- —— Separates land categories

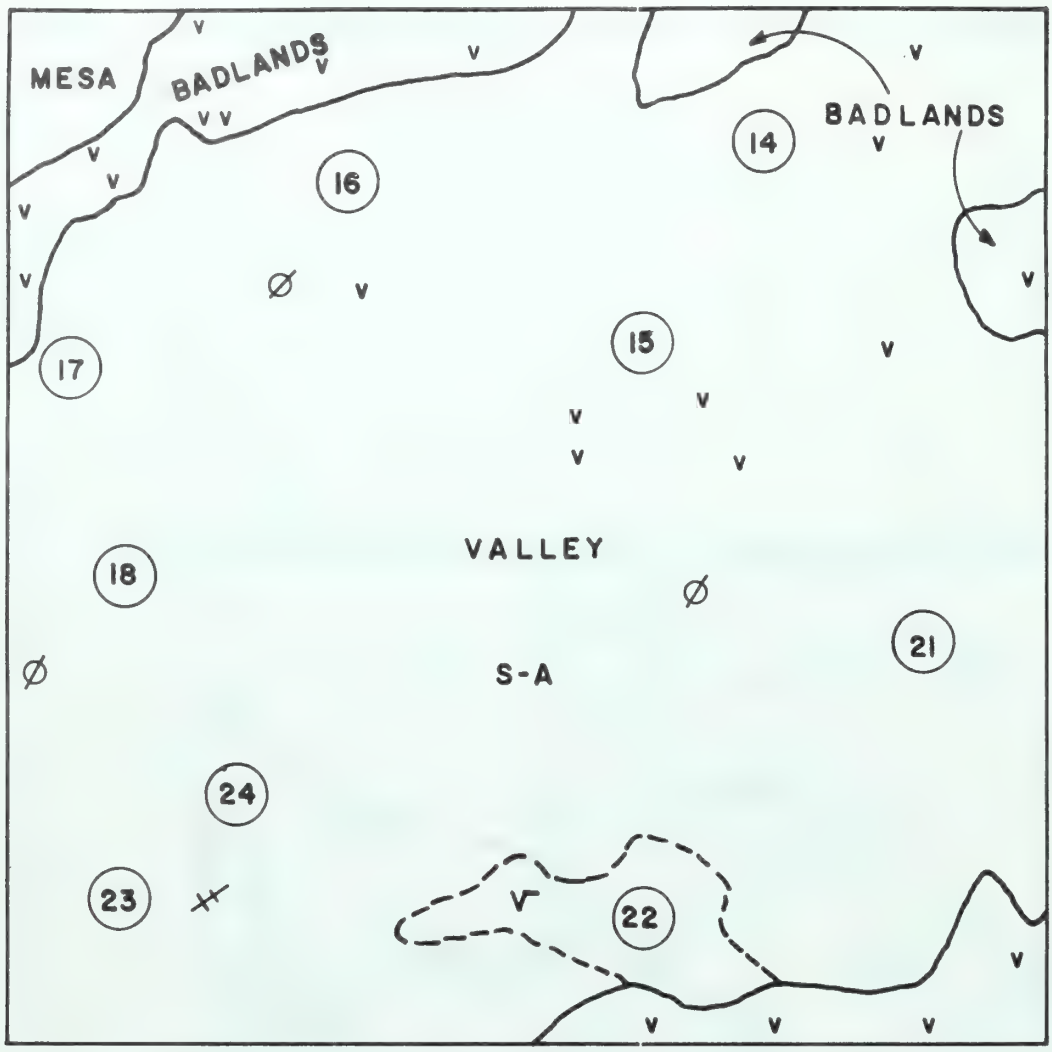
MAJOR LAND CATEGORIES

	acres
MESA	245
BADLANDS	64
VALLEY	
sandy	
s-a saline sodic	11
MISCELLANEOUS	
Active Dunes	
Hummocky	
Stream Channel	
TOTAL	320

SECTION 26

EMRIA REPORT NO. 17-77

FIGURE Q-22



1000 500 0 1000 2000

SCALE IN FEET

Mapping Symbols

- Hummocks
- Blowout
- Clay spot
- Gravelly spot
- Gumbo, Slick or scaby spot (sodic)
- V – Rock Outcrop (includes shale and sandstone)
- V. – Baked rock (scoria)
- # – Greasewood
- ③ – Profiles
- ⊗ – Check holes
- ------ Separates valley subcategories
- —— Separates land categories

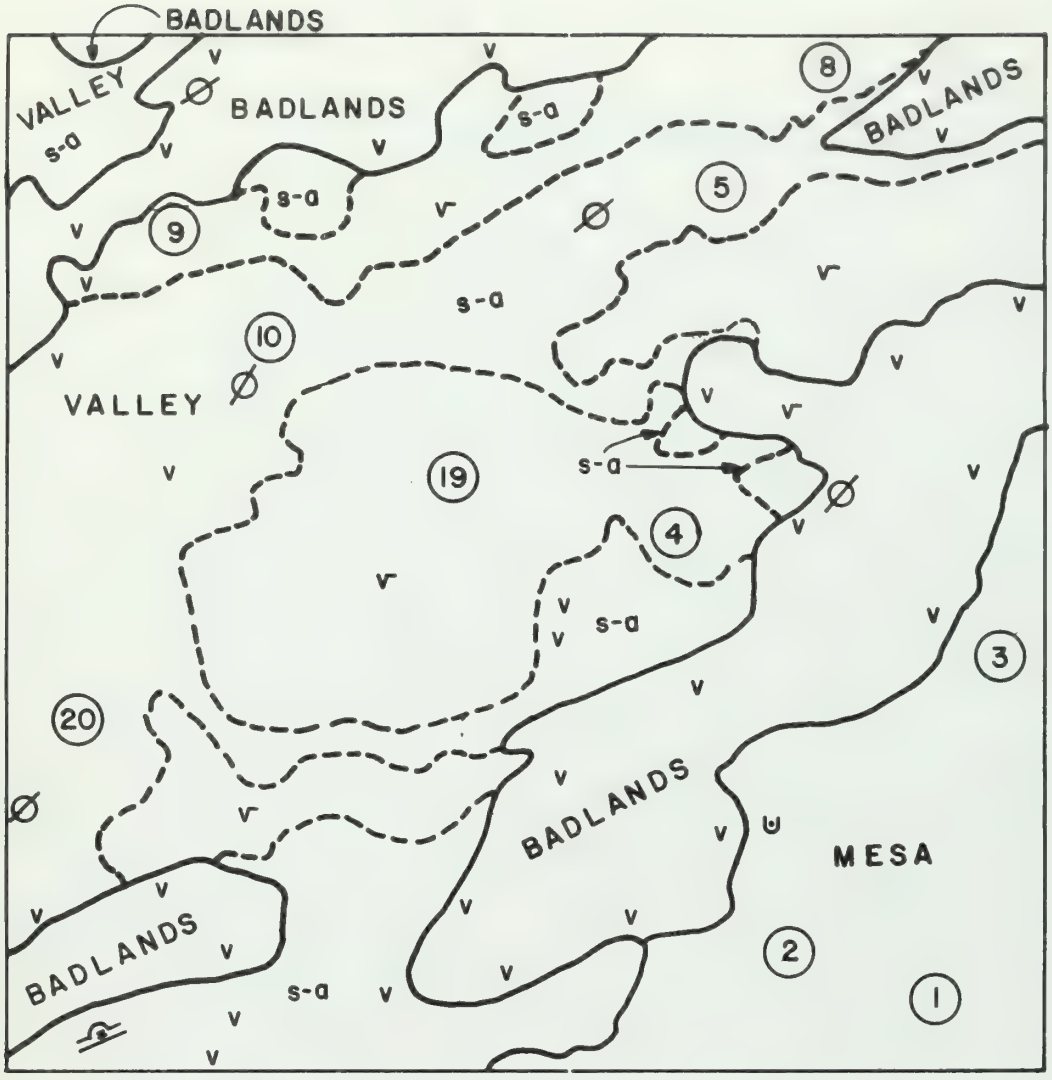
MAJOR LAND CATEGORIES

	acres
MESA	9
BADLANDS	120
VALLEY	
sandy	19
s-a saline sodic	492
MISCELLANEOUS	
Active Dunes	
Hummocky	
Stream Channel	
TOTAL	640

SECTION 25

EMRIA REPORT NO. 17-77

FIGURE Q-23



1000 500 0 1000 2000

SCALE IN FEET

Mapping Symbols

- Hummocks
- ⊍ – Blowout
- Clay spot
- Gravelly spot
- Gumbo, Slick or scaby spot (sodic)
- V – Rock Outcrop (includes shale and sandstone)
- V. – Baked rock (scoria)
- # – Greasewood
- ③ – Profiles
- ⊗ – Check holes
- ------ Separates valley subcategories
- —— Separates land categories

MAJOR LAND CATEGORIES

	acres
MESA	83
BADLANDS	143
VALLEY	
sandy	159
s-a saline sodic	255
MISCELLANEOUS	
Active Dunes	
Hummocky	
Stream Channel	
TOTAL	640

SECTION 30

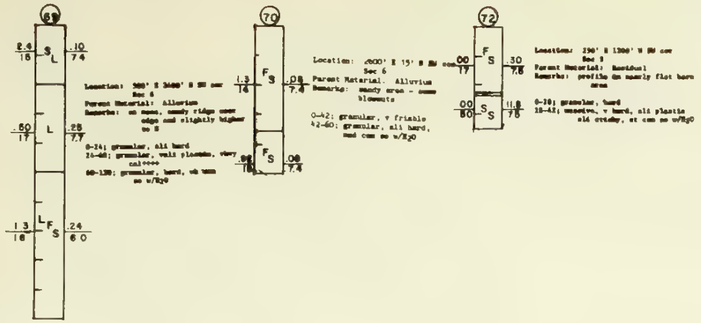
EMRIA REPORT NO. 17-77

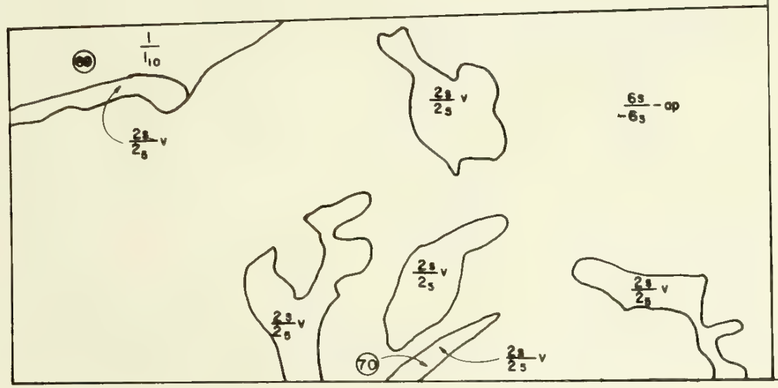
FIGURE Q-24

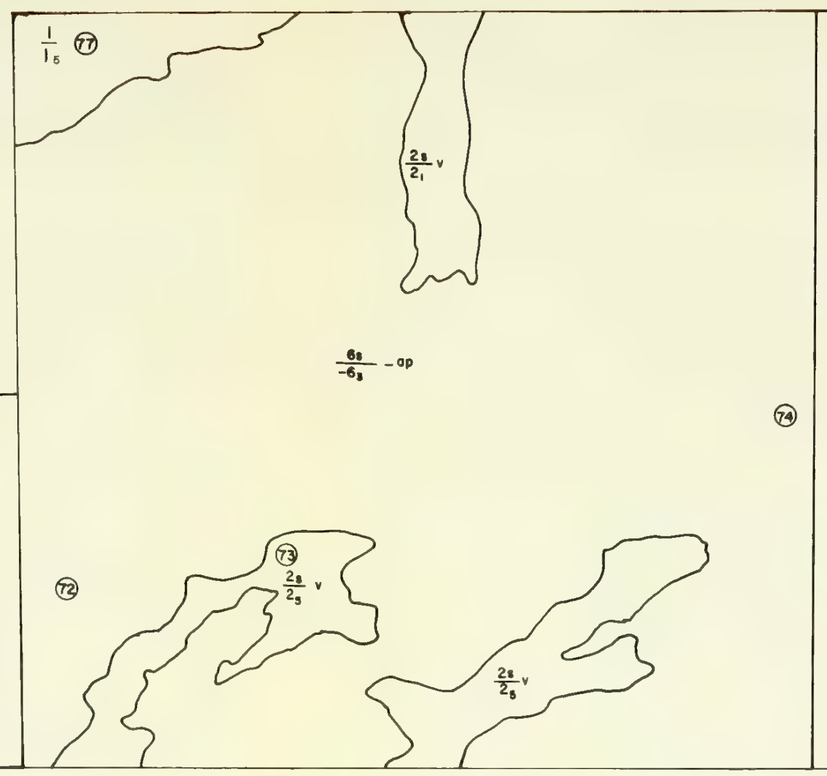
Table Q-2
LAND CLASSIFICATION RESULTS
(Acres)

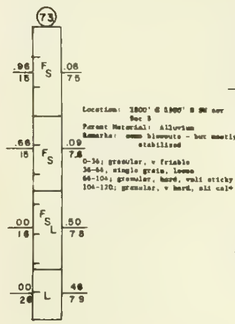
(All land in T22N)

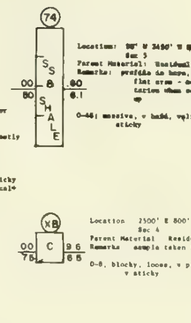
Subclasses	R11W Sec. 12	R10W 4	5	6	7	8	9	10	11	13	14	15	16	17	18	19	22	23	24	25	26	27	R9W 19	30	TOTAL
1/1$_{10}$				16																				69	85
1/1$_5$	3	62	12		52	6									29										164
1/1$_{72_2}$ V																	6	232	331	9	245	115	36		974
1/1$_{62_4}$ V										3	117						240	44							404
1/1$_{32_7}$ V	51						126	31	67				239	477	188	82									1,261
Class 1	54	62	12	16	52	6	126	31	67	3	117		239	477	217	82	246	276	331	9	245	115	36	69	2,888
2s/2$_{10}$ V									13			84											17	64	178
2s/2$_5$ V	4		54	39	27	30						74				18									246
2s/2$_3$ V										18	24							3		19					64
2s/2$_1$ V			16																						16
2s/2$_5$ a	36								41		6					38				14	11				146
2s/2$_{63}$ vk																	103	96	78			33			310
2s/2$_{565}$ vp											107	134												95	336
2s/2$_{13-62}$ h-ap	6																								6
2s/2$_{164-63}$ ap-ap																			2						2
2s/2$_{1622_3}$ vpv							1	11				4	25												41
2s/2$_{662-62}$ vp-ap																			1				22		23
2s/2$_{2626_1-61}$ ap-ap		13																							13
Class 2	46	13	70	39	27	30	1	11	54	18	137	296	25			56	103	99	81	33	11	33	39	159	1,381
Total Class 1 & 2	100	75	82	55	79	36	127	42	121	21	254	296	264	477	217	138	349	375	412	42	256	148	75	228	4,269
6s/6s K								11		13		63	48				55	74	30						294
6s/6$_{10}$ p											2	136	132				3		13	93			1	8	388
6s/6$_{10}$ ap										63										458				238	759
6s/6s ap					22		40	3																	65
6s/−63 −ap	540	565	558	265	520	573	458	34	5	12	363	28	192	46		181	52	22	107	47	64		244	150	5,026
6s/6s av									22	51	14	115	4				116	153	78			12			565
6s/6$_{624}$ pv								70				2													72
6s/6$_{862}$ sap																								16	16
6s/6$_{8-62}$ ap-ap									12		7							12							31
6s/6$_{3-67}$ ap-ap																	65	4							69
6s/6$_{1-64}$ ap-ap					19	31								117	423	1									591
6s/6$_{1,23}$ psa							15																		15
Class 6	540	565	558	265	561	604	513	118	39	139	386	344	376	163	423	182	291	265	228	598	64	12	245	412	7,891
Total Class 1, 2 & 6	640	640	640	320	640	640	640	160	160	160	640	640	640	640	640	320	640	640	640	640	320	160	320	640	12,160

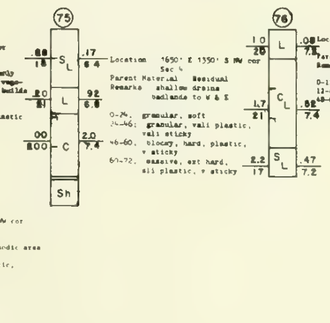

69
70
72
Location: 2600' E 15' S NW cor Sec 6
Parent Material: Alluvium
Remarks: sandy area - some blowouts
0-42; granular, v friable
42-60; granular, all hard, mod cem no w/Hg0
Location: 250' E 1300' N NW cor Sec 5
Parent Materials: Residual
Remarks: profile on nearly flat bare area
0-20; granular, hard
20-42; massive, v hard, all plastic old eroday, st cem no w/Hg0
Location: 1800' E 1800' S NW cor Sec 5
Parent Material: Alluvium
Remarks: some blowouts - but mostly stabilized
0-36; granular, v friable
36-64, single grain, loose
64-104; granular, hard, vall sticky
104-120; granular, v hard, all cal
Location: 900' E 2400' S NW cor Sec 6
Parent Material: Alluvium
Remarks: on mesa, sandy ridge crest edge and slightly higher on S
0-24; granular, all hard
24-48; granular, vall plastic, very cal
48-130; granular, hard, sh lens no w/Hg0

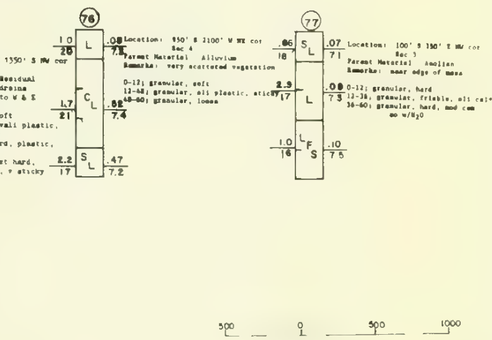





73
.96/15 FS .08/7.5
.66/15 FS .09/7.6
.00/16 FSL .50/7.8
.00/20 L 46/7.9
0-36; granular, v friable
36-64, single grain, loose
64-104; granular, hard, vall sticky
104-120; granular, v hard, all cal
Location: 1800' E 1800' S NW cor Sec 5
Parent Material: Alluvium
Remarks: some blowouts - but mostly stabilized

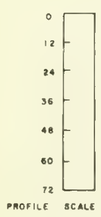

74
.00/80 SS
SHALE .80/8.1
0-48; massive, v hard, vvall plastic sticky
Location: 900' W 2450' S NE cor Sec 5
Parent Material: Unaltered
Remarks: profile in bowl, usually flat area - some vegetation when good builds up
XB
.00/75 C .96/8.5
0-8, blocky, loose, v plastic, v sticky
Location 2500' E 800' S NW cor Sec 4
Parent Material Residue.
Remarks sample taken in arctic area


75
.88/18 SL .17/6.4
.20/81 L .92/6.8
.00/100 C 2.0/7.4
Sh
Location: 1650' E 1350' S NW cor Sec 4
Parent Material: Residual
Remarks: shallow drains badlands to W & E
0-24, granular, soft
24-46; granular, vall plastic, vall sticky
46-60, blocky, hard, plastic, v sticky
60-72, massive, ext hard, all plastic, v sticky



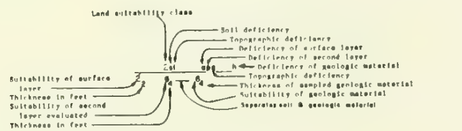
77
.86/18 SL .07/7.1
2.9/17 L .08/7.3
1.0/16 FS .10/7.5
Location: 100' S 150' E NW cor Sec 3
Parent Material Aeolian
Remarks: near edge of mesa
0-12; granular, hard
12-36; granular, friable, all cal
36-60; granular, hard, mod cem no w/Hg0

500 0 500 1000
MAP SCALE IN FEET
(Approximate)



PROFILE SCALE IN INCHES

Mapping and Profile Symbols for Land Classification

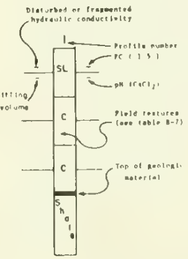


Land class suitability
1 good
2 poor
3 unsuitable

Subclasses
s - soils
t - topography

Subclass deficiency
v - very coarse texture
e - erodic
p - permeability
s - saline
h - shallow depth to coarse sand, gravel, or cobble
s - slope

Profile Description



Textures
S sand
FS fine sand
VFS very fine sand
LFS loamy fine sand
LS loamy sand
FSL fine sandy loam
SL sandy loam
L loam
SIL silty loam
CL clay loam
SiCL silty clay loam
SCL sandy clay loam
SiC silty clay
SC sandy clay
C clay
Sh shale
SS sandstone

LEGEND

2s/2s2s6s Land Class

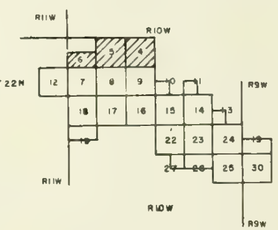
(3) PROFILES

Separates Classes

- - - - Separates Subclasses

LAND CLASS**	ACRES
1	90
2	122
Total	212
6	1388
GRAND TOTAL	1600

** For complete acreage of each individual land classification see table Q-2



* Lands were classified for their suitability as a source of planting media

ALWAYS THINK SAFETY

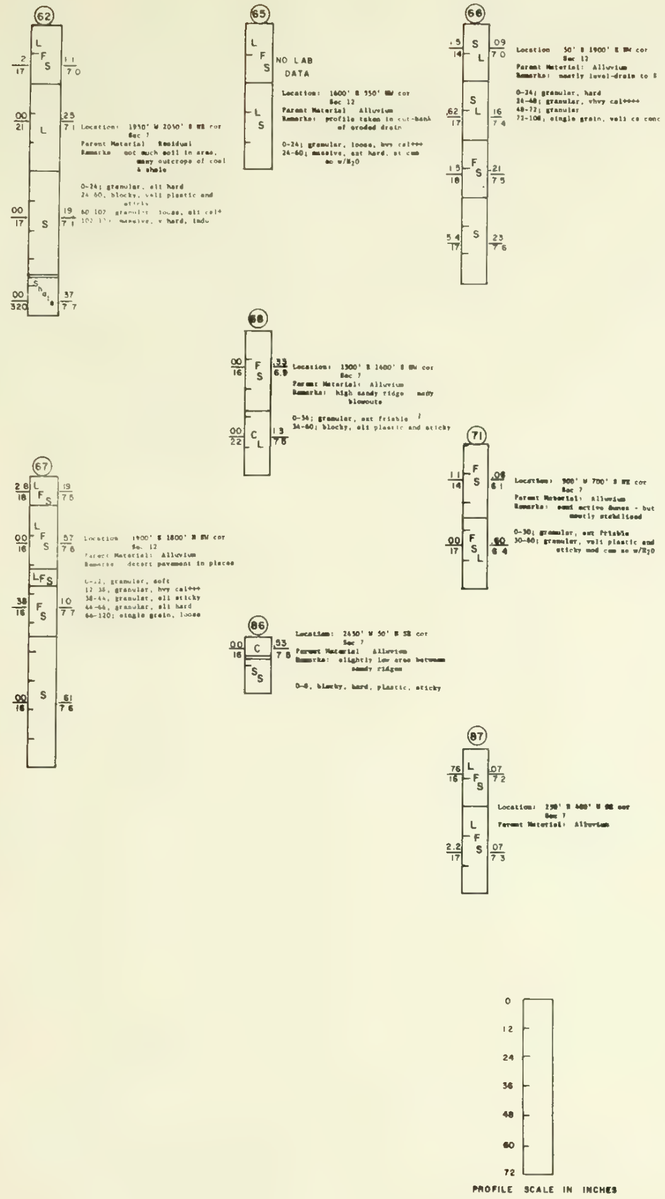
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

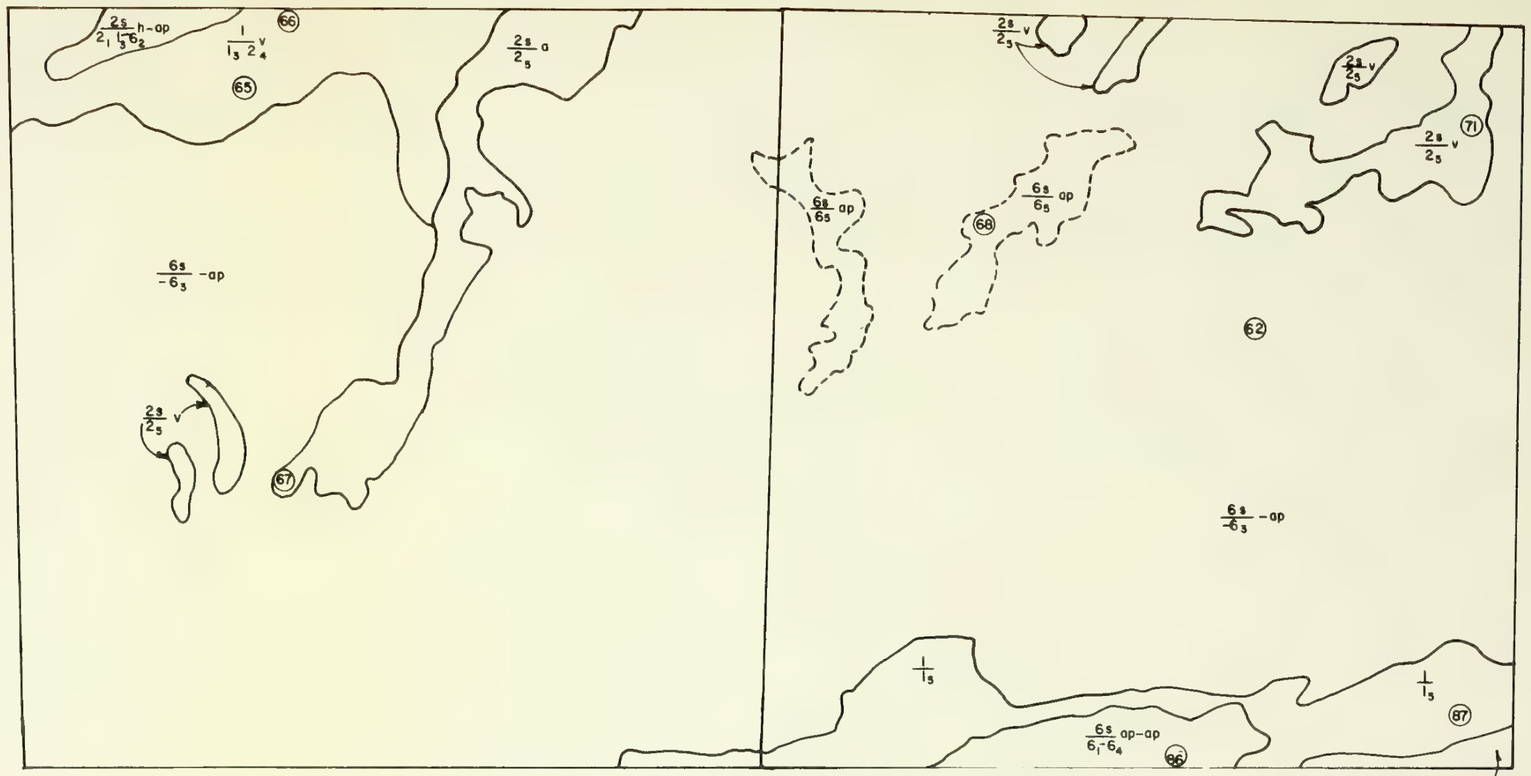
EMRIA REPORT NO. 17-77
KIMBETO STUDY AREA - NEW MEXICO

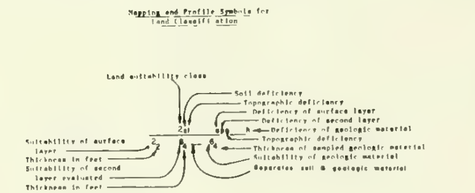
PROFILE DESCRIPTIONS AND LAND CLASSIFICATION*

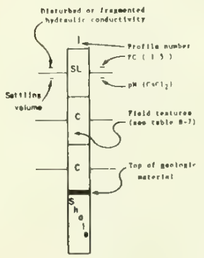
DESIGNED	SUBMITTED
DRAWN	RECOMMENDED
CHECKED	APPROVED

AMARILLO, TEXAS — FEBRUARY 1979 — FIGURE No Q-25


(62)
Location: 1950' W 2050' S NE cor Sec 7
Parent Material Residual
Remarks not much soil in area, many outcrops of coal & shale
0-24; gramular, slt hard
24-80, blocky, vslt plastic and stic
80-107 granular loamy, slt cal+
107-17+ massive, v hard, indu
(65)
NO LAB DATA
Location: 1600' S 550' NW cor Sec 12
Parent Material Alluvium
Remarks: profile taken in cut-bank of eroded drain
0-24; granular, loose, hvy cal+++
24-60; massive, sft hard, sl cem mo w/H2O
(66)
Location 50' S 1900' E NW cor Sec 12
Parent Material: Alluvium
Remarks: nearly level-drain to S
0-24; granular, hard
24-48; granular, vhvy cal++++
48-73; granular
73-106; single grain, vslt co conc
(68)
Location: 1300' S 1600' E NW cor Sec 7
Parent Material: Alluvium
Remarks: high sandy ridge mostly blowouts
0-34; granular, sft friable
34-60; blocky, slt plastic and sticky
(71)
Location: 900' W 700' S NE cor Sec 7
Parent Material: Alluvium
Remarks: semi active dunes - but mostly stabilized
0-30; granular, sft friable
30-80; granular, vslt plastic and sticky mod cem mo w/H2O
(67)
Location 1900' E 1800' N NW cor Sec. 12
Parent Material: Alluvium
Remarks desert pavement in places
0-12, granular, soft
12-38, granular, hvy cal+++
38-64, granular, sli sticky
64-84, granular, slt hard
84-120; single grain, loose
(86)
Location: 2430' W 50' N SE cor Sec 7
Parent Material Alluvium
Remarks: slightly low area between sandy ridges
0-8, blocky, hard, plastic, sticky
(87)
Location: 190' E 600' N SE cor Sec 7
Parent Material: Alluvium
0
12
24
36
48
60
72
PROFILE SCALE IN INCHES







LEGEND

2s/2 3 VS Land Class

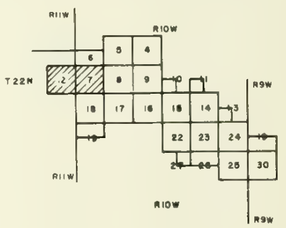
(3) PROFILES

Separates Classes

Separates Subclasses

LAND CLASS**	ACRES
1	106
2	73
Total	179
6	1101
GRAND TOTAL	1280

** For complete acreage of each individual land classification see table Q-2



* Lands were classified for their suitability as a source of planting media

ALWAYS THINK SAFETY

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

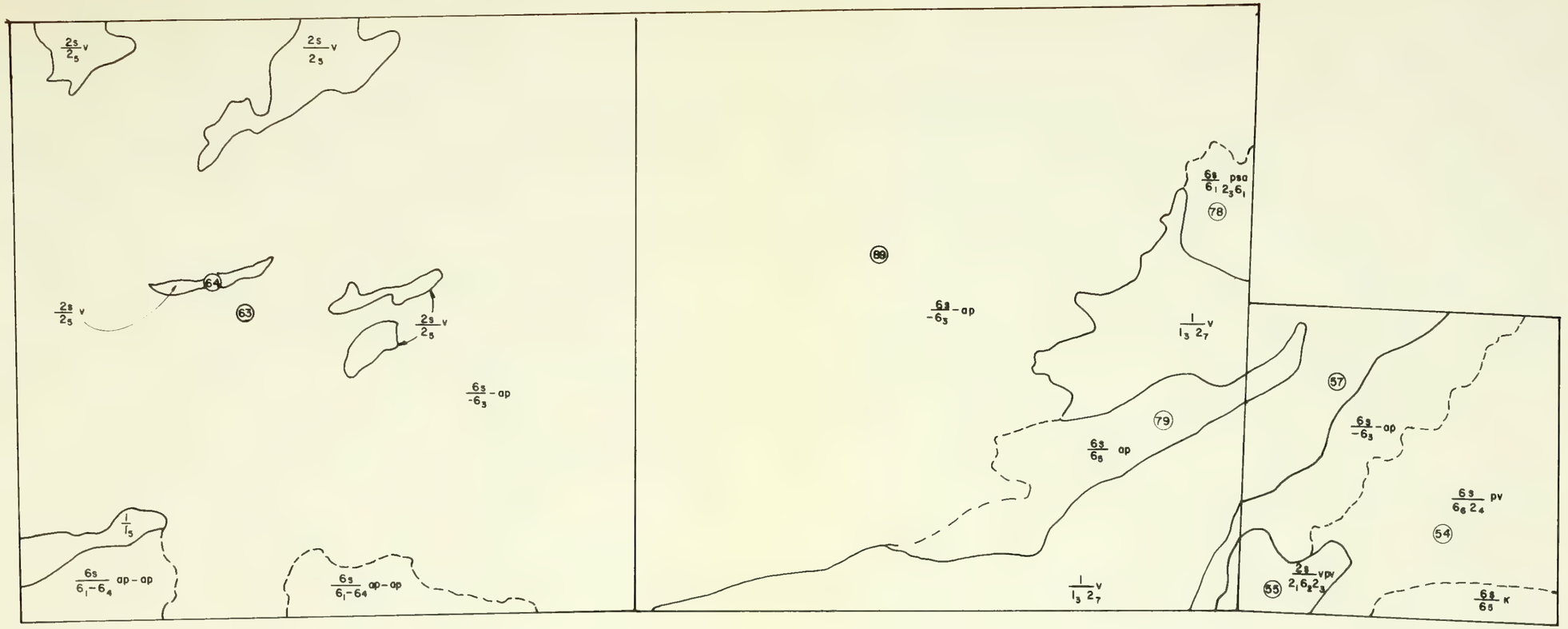
EMRIA REPORT NO. 17-77

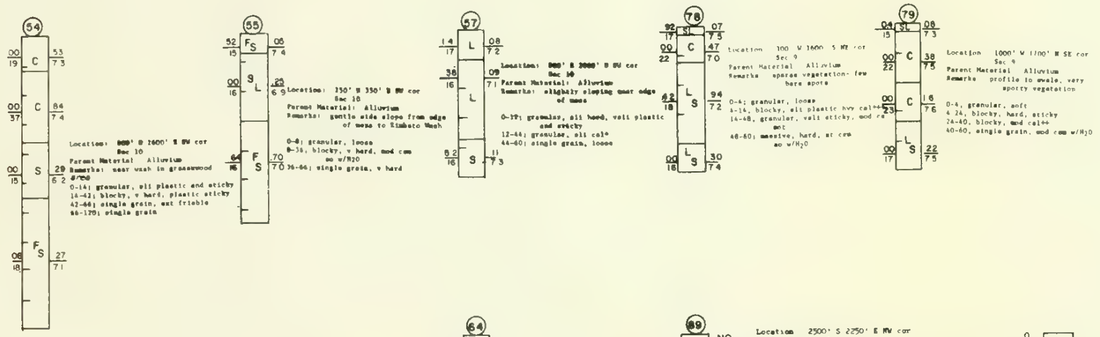
KIMBETO STUDY AREA - NEW MEXICO

PROFILE DESCRIPTIONS AND LAND CLASSIFICATION *

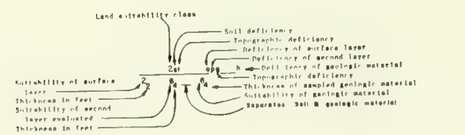
DESIGNED		SUBMITTED	
DRAWN		RECOMMENDED	
CHECKED		APPROVED	

AMARILLO, TEXAS — FEBRUARY 1979 — FIGURE No. Q-26




54
Location: 800' S 2600' E NW cor Sec 10
Parent Material: Alluvium
Remarks: near wash in grassswood drainage
0-14; granular, slt plastic and sticky
14-43; blocky, v hard, plastic sticky
43-66; single grain, wet friable
66-179; single grain
55
Location: 350' N 350' E SW cor Sec 10
Parent Material: Alluvium
Remarks: gentle side slope from edge of mesa to Kimbeto Wash
0-8; granular, loose
8-36; blocky, v hard, mod cem w/H2O
36-66; single grain, v hard
57
Location: 800' S 2000' E SW cor Sec 10
Parent Material: Alluvium
Remarks: slightly sloping east edge of mesa
0-19; granular, slt hard, vslt plastic and sticky
12-44; granular, slt calc*
44-60; single grain, loose
78
Location 100' W 1600' S NE cor Sec 9
Parent Material Alluvium
Remarks sparse vegetation- few bare spots
0-4; granular, loose
4-14, blocky, slt plastic hvy calc*
14-48, granular, vslt sticky, mod cem wet
48-80; massive, hard, sl cem wo w/H2O
79
Location 1000' W 1700' N SE cor Sec 9
Parent Material Alluvium
Remarks profile in swale, very sparcy vegetation
0-4, granular, soft
4-24, blocky, hard, sticky
24-40, blocky, mod calc*
40-60, single grain, mod cem w/H2O
63
Location: 1000' S 2600' W NW cor Sec 8
Parent Material: Residual
Remarks: numerous shallow drains
0-24; granular, loose, slt calc*
24-48; massive, v hard, plastic v sticky
64
Location: 1700' S 2200' E NW cor Sec 8
Parent Material: Aeolian
Remarks: shallow blowouts
0-20, granular, v friable
20-54, single grain, loose slt calc*
89
NO LAB DATA
Location 2500' S 2250' E NW cor Sec 9
Parent Material Residual
Remarks typical profile of badlands area
0-12, blocky, hard, plastic, sticky
0
12
24
36
48
60
72
PROFILE SCALE IN INCHES

Mapping and Profile Symbols for Land Classification

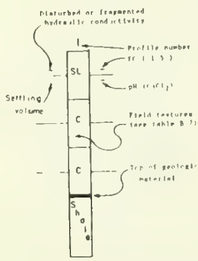


Land class suitability
1 - good
2 - poor
3 - unsuitable

Subclasses
s - soils
t - topography

Soil deficiency
w - very coarse texture
o - acidic
p - permeability
a - saline
b - shallow depth to coarse sand, gravel, or cobble
R - slope

Profile Description



Textures

S	sand
FS	fine sand
VFS	very fine sand
LFS	loamy fine sand
LS	loamy sand
FSL	fine sandy loam
SL	sandy loam
L	loam
SiL	silty loam
Cl	clay loam
SiCl	silty clay loam
SCL	sandy clay loam
SiC	silty clay
SC	sandy clay
C	clay
Sh	shale
SS	sandstone

LEGEND

2s/2₃1²6₅ vs Land Class

(3) PS- FILES

Separates Classes

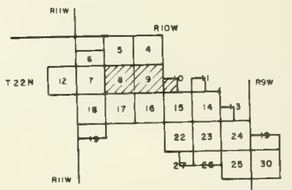
Separates Subclasses

LAND CLASS**	ACRES
1	163
2	57
Total	220
6	1220
GRAND TOTAL	1440

** For complete acreage of each individual land classification see table Q-2

500 0 500 1000

MAP SCALE IN FEET (Approximate)



* Lands were classified for their suitability as a source of planting media

ALWAYS THINK SAFETY

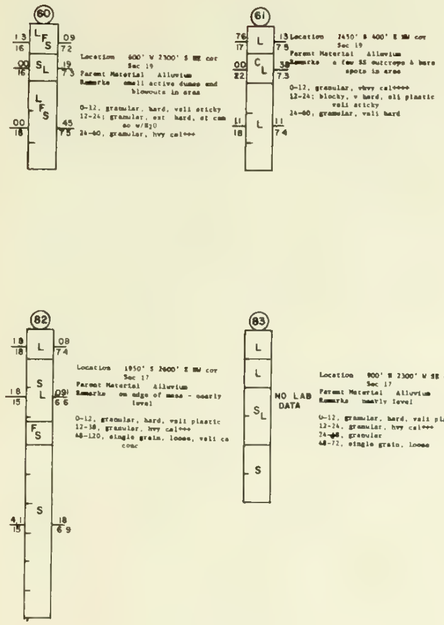
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

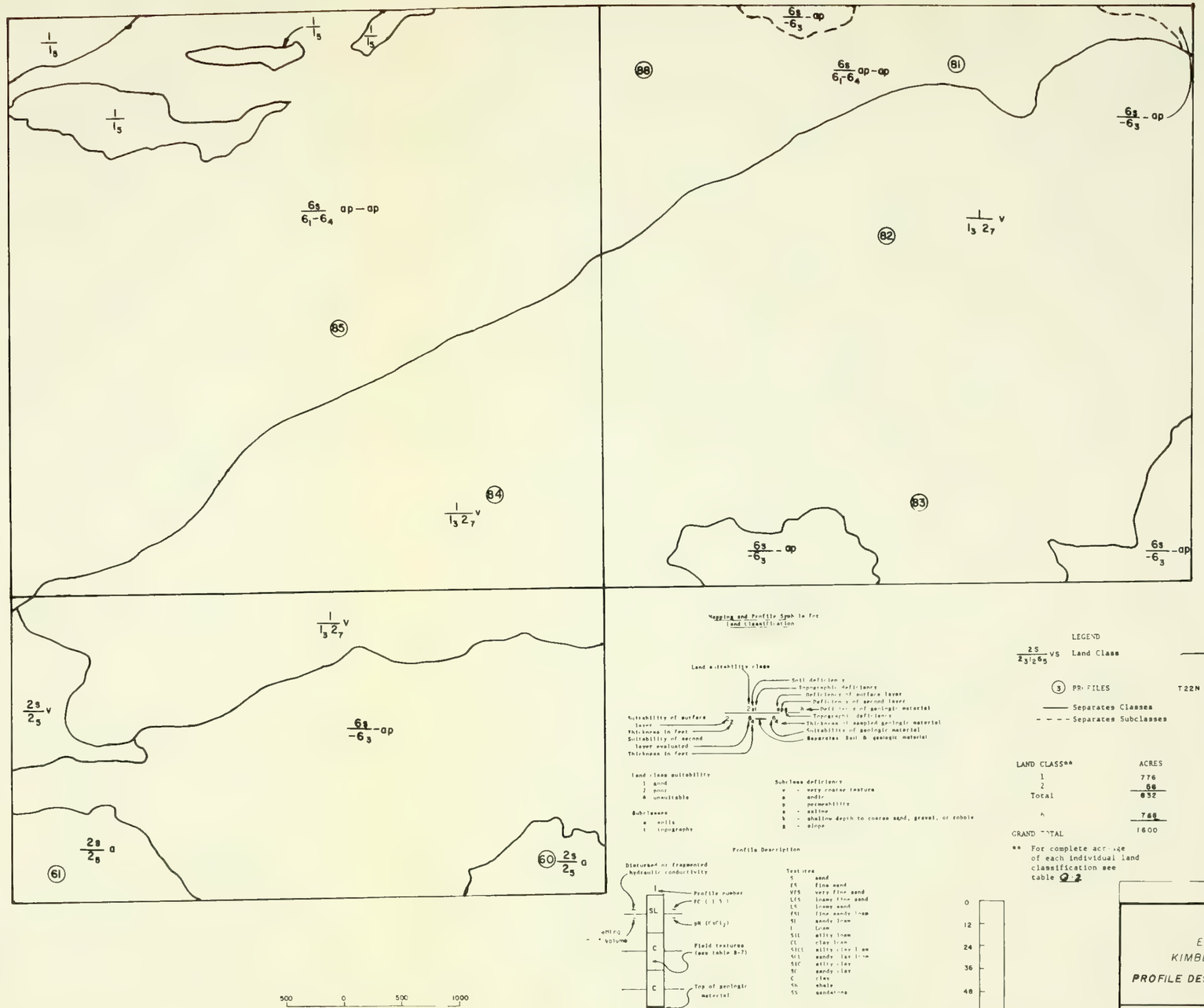
EMRIA REPORT NO 17-77
KIMBETO STUDY AREA - NEW MEXICO

PROFILE DESCRIPTIONS AND LAND CLASSIFICATION *

DESIGNED	SUBMITTED
DRAWN	RECOMMENDED
CHECKED	APPROVED
AMARILLO, TEXAS	FEBRUARY 1979

FIGURE No Q-27





500 0 500 1000
MAP SCALE IN FEET
(Approximate)

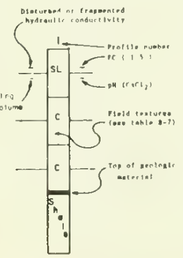
Mapping and Profile Symbols for Land Classification

Land class suitability
1 good
2 poor
6 unsuitable

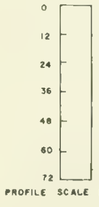
Subclasses
e - wells
t - topography

Subclass deficiency
v - very coarse texture
e - aeolic
p - permeability
s - saline
h - shallow depth to coarse sand, gravel, or cobble
g - slope

Profile Description



Texture
S sand
FS fine sand
VFS very fine sand
LFS loamy fine sand
LS loamy sand
FSL fine sandy loam
SL sandy loam
L loam
SiL silty loam
CL clay loam
SiCL silty clay loam
SCL sandy clay loam
SiC silty clay
SC sandy clay
C clay
Sh shale
SS sandstone



PROFILE SCALE IN INCHES

LEGEND

2S/2s3s2s5 VS Land Class

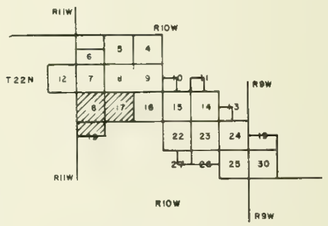
(3) PROFILES

——— Separates Classes

- - - - Separates Subclasses

LAND CLASS**	ACRES
1	776
2	56
Total	832
h	768
GRAND TOTAL	1600

** For complete acreage of each individual land classification see table Q-2



* Lands were classified for their suitability as a source of planting media

ALWAYS THINK SAFETY

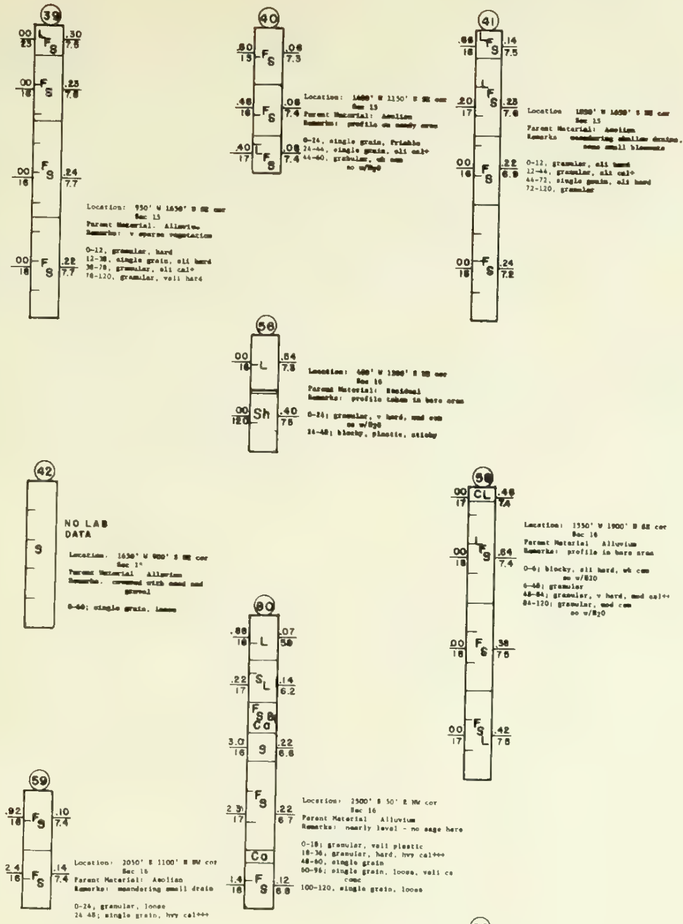
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

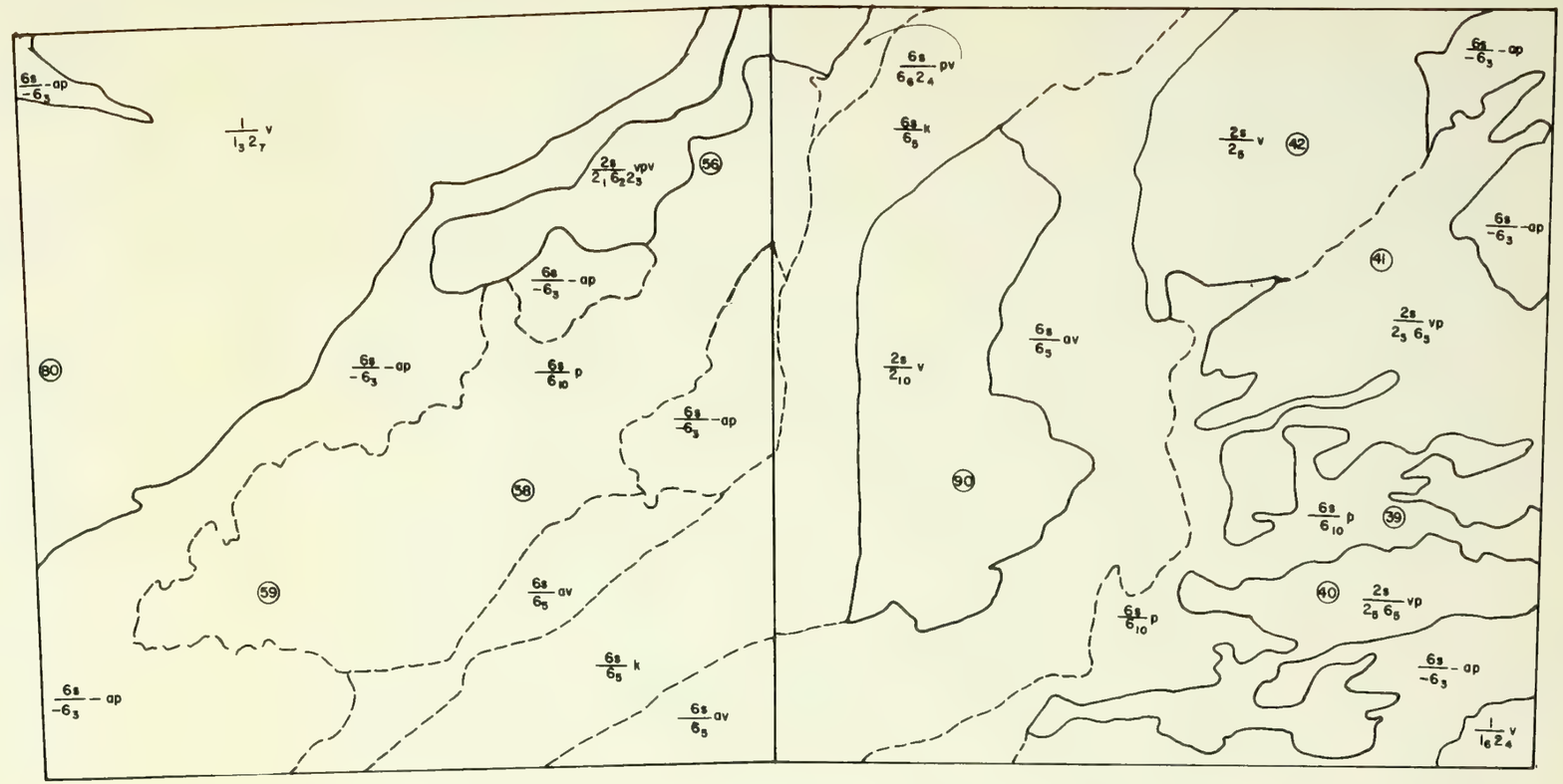
EMRIA REPORT NO 17-77
KIMBETO STUDY AREA - NEW MEXICO

PROFILE DESCRIPTIONS AND LAND CLASSIFICATION *

DESIGNED	SUBMITTED
DRAWN	RECOMMENDED
CHECKED	APPROVED

AMARILLO, TEXAS — FEBRUARY 1979 — FIGURE No. Q-28

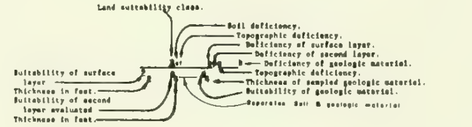

39
Location: 950' W 1650' S NE cor Sec 13
Parent Material: Alluvium
Remarks: v sparse vegetation
0-12, granular, hard
12-30, single grain, sli hard
30-78, granular, sli cal+
78-120, granular, well hard
40
Location: 1650' W 1150' S NE cor Sec 13
Parent Material: Aeolian
Remarks: profile on sandy area
0-24, single grain, friable
24-44, single grain, sli cal+
44-60, granular, sh cem
no w/Hcl
41
Location: 1250' W 1650' S NE cor Sec 13
Parent Material: Aeolian
Remarks: meandering shallow drains, some small blowouts
0-12, granular, sli hard
12-44, granular, sli cal+
44-72, single grain, sli hard
72-120, granular
56
Location: 400' W 1300' S NE cor Sec 16
Parent Material: Residual
Remarks: profile taken in bare area
0-24; granular, v hard, mod cem
no w/Hcl
24-48; blocky, plastic, sticky
42
NO LAB DATA
Location: 1650' W 900' S NE cor Sec 1*
Parent Material: Alluvium
Remarks: cemented with caked sand gravel
0-60; single grain, loose
58
Location: 1550' W 1900' S NE cor Sec 16
Parent Material: Alluvium
Remarks: profile in bare area
0-6; blocky, sli hard, wk cem
no w/Hcl
6-48; granular
48-84; granular, v hard, mod cal+
84-120; granular, mod cem
no w/Hcl
60
Location: 1500' S 50' E NW cor Sec 16
Parent Material: Alluvium
Remarks: nearly level - no sage here
0-18; granular, well plastic
18-36, granular, hard, hvy cal+
48-80, single grain
80-96; single grain, loose, well ce mented
100-120, single grain, loose
59
Location: 2050' S 1100' E NW cor Sec 18
Parent Material: Aeolian
Remarks: meandering small drain
0-24, granular, loose
24-48; single grain, hvy cal+
90
NO LAB DATA
Location: 1300' E 1650' N SW cor Sec 13
Parent Material: Aeolian
Remarks: profile located in active dunes area
0-60, single grain, loose



500 0 500 1000
MAP SCALE IN FEET (Approximate)

0 12 24 36 48 60 72
PROFILE SCALE IN INCHES

Mapping and Profile Symbols for Land Classification

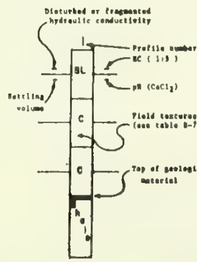


Land class suitability
1 good
2 poor
6 unsuitable

Subclasses
s - soils
t - topography

Subclass deficiency
v - very coarse texture
a - aeolic
p - permeability
s - saline
h - shallow depth to coarse sand, gravel, or cobble
s - slope

Profile Description



Textures
S sand
FS fine sand
VFS very fine sand
LFS loamy fine sand
LS loamy sand
FSL fine sandy loam
SL sandy loam
L Loam
SIL silty loam
CL clay loam
SICL silty clay loam
SCL sandy clay loam
SIC silty clay
SC sandy clay
C clay
Sh shale
Ss sandstone

LEGEND

$\frac{2s}{2_3 6_5 6_s}$ VS Land Class

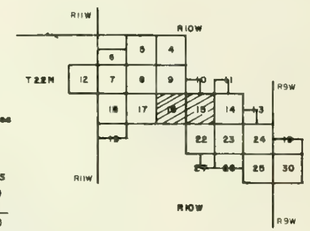
(3) PROFILES

——— Separates Classes

- - - - Separates Subclasses

LAND CLASS**	ACRES
1	239
2	321
Total	560
6	720
GRAND TOTAL	1280

** For complete acreage of each individual land classification see table Q-2



* Lands were classified for their suitability as a source of planting media

ALWAYS THINK SAFETY

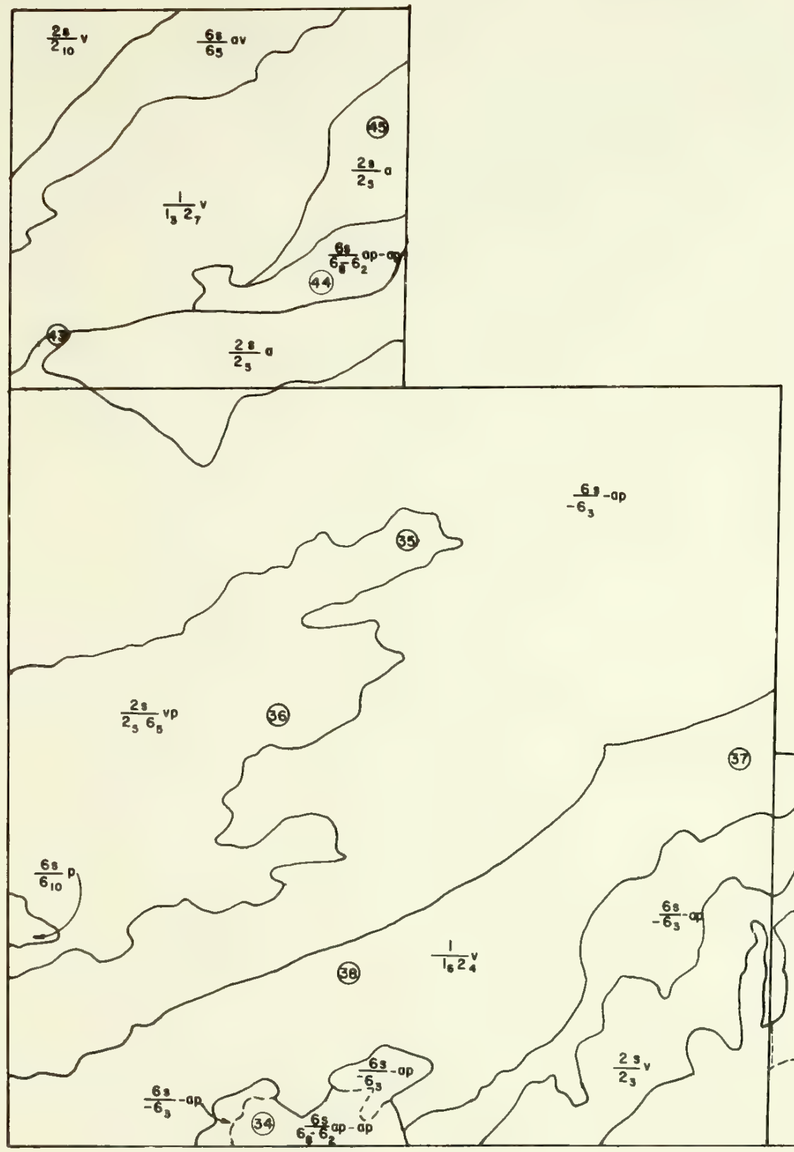
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

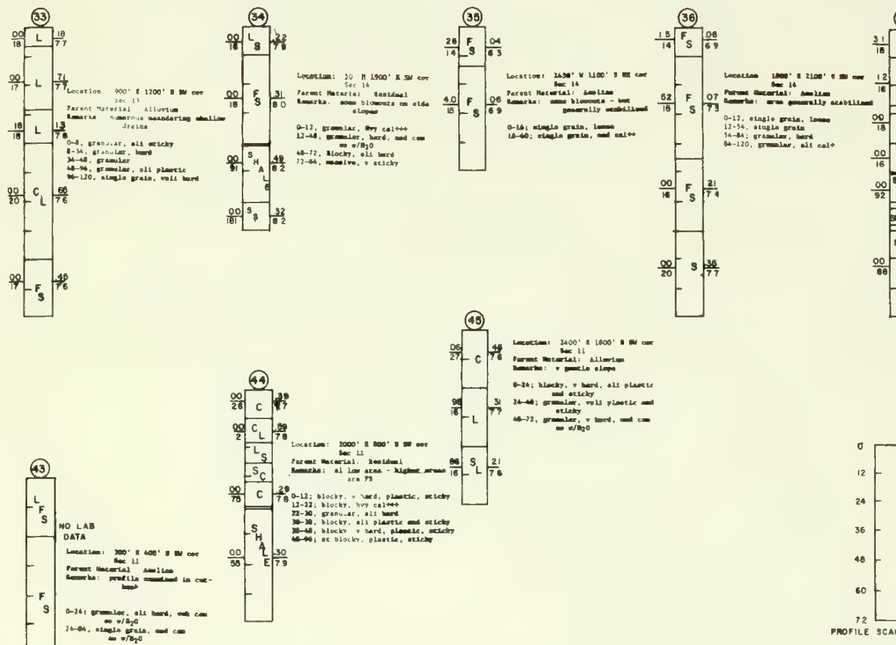
EMRIA REPORT NO. 17-77
KIMBETO STUDY AREA - NEW MEXICO

PROFILE DESCRIPTIONS AND LAND CLASSIFICATION*

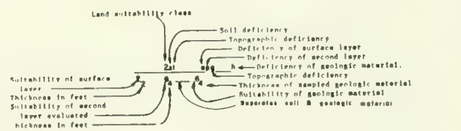
DESIGNED ... SUBMITTED ...
DRAWN ... RECOMMENDED ...
CHECKED ... APPROVED ...

AMARILLO, TEXAS FEBRUARY 1979 FIGURE No Q-29

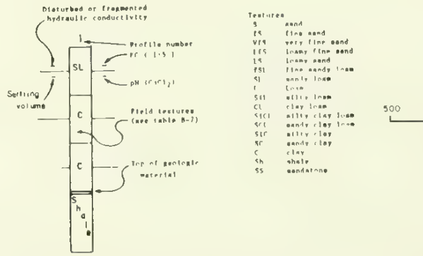



33
Location: 900' E 1200' S SW cor sec 13
Parent Material: Alluvium
Remarks: numerous meandering shallow drains
0-8, granular, slt sticky
8-34, granular, hard
34-48, granular
48-96, granular, slt plastic
96-120, single grain, vslt hard
34
Location: 30 N 1900' E SW cor Sec 14
Parent Material: Residual
Remarks: some blowouts on side slopes
0-12, granular, hvy cal++
12-48, granular, hard, mod cem ox w/Fe2O
48-72, blocky, slt hard
72-84, massive, v sticky
35
Location: 2430' W 1100' S NE cor Sec 14
Parent Material: Aeolian
Remarks: some blowouts - but generally stabilized
0-18; single grain, loose
18-60; single grain, mod cal++
36
Location: 1800' E 2100' S SW cor Sec 14
Parent Material: Aeolian
Remarks: area generally stabilized
0-12, single grain, loose
12-54, single grain
54-84, granular, hard
84-120, granular, slt cal+
37
Location: 2450' E 300' S SE cor Sec 14
Parent Material: Residual
Remarks: mesa built up near edge of mesa both N & S
0-12, single grain, loose
12-32, granular, hard
32-48, granular, mod ca cmt
48-60, granular, mod cal++
60-74, blocky, v hard
74-88, mt blocky
88-120, mt blocky, plastic, sticky
38
Location: 2380' E 1600' S SW cor Sec 14
Parent Material: Alluvium
Remarks: mod small blowouts
0-24; single grain, loose
24-54; single grain, hard
54-90; blocky slt plastic mod sticky
90-120, single grain, loose
43
NO LAB DATA
Location: 300' E 400' S SW cor Sec 11
Parent Material: Aeolian
Remarks: profile examined in cut-bank
0-24; grannular, slt hard, vesh cem ox w/Fe2O
24-84, single grain, mod cem ox w/Fe2O
44
Location: 3000' E 800' S SW cor Sec 11
Parent Material: Residual
Remarks: slt low area - highest areas are 7S
0-12; blocky, v hard, plastic, sticky
12-22; blocky, hvy cal++
22-36, granular, slt hard
36-38, blocky, slt plastic and sticky
38-48, blocky v hard, plastic, sticky
48-96; mt blocky, plastic, sticky
45
Location: 2400' E 1800' S SW cor Sec 11
Parent Material: Alluvium
Remarks: v gentle slope
0-24; blocky, v hard, slt plastic and sticky
24-48; granular, vslt plastic and sticky
48-72, granular, v hard, mod cem ox w/Fe2O
PROFILE SCALE IN INCHES

Mapping and Profile Symbols for Land Classification



Profile Description



LEGEND

2s/2 3 t 2 6 5 VS Land Class

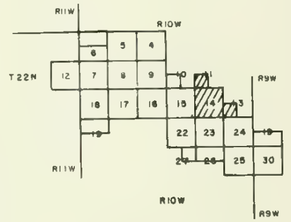
(3) PROFILES

Separates Classes

Separates Subclasses

LAND CLASS**	ACRES
1	120
2	276
Total	396
6	564
GRAND TOTAL	960

** For complete acreage of each individual land classification see table Q-2



* Lands were classified for their suitability as a source of planting media

MAP SCALE IN FEET (Approximate)

ALWAYS THINK SAFETY

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

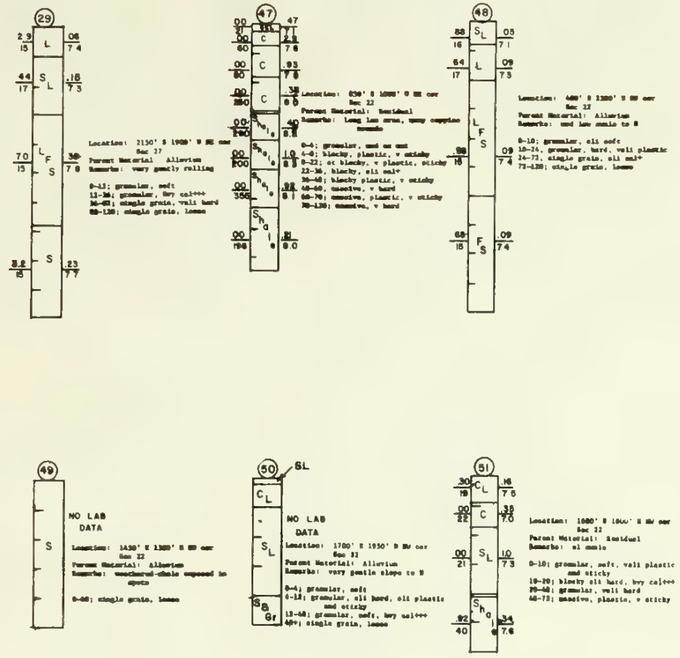
EMRIA REPORT NO 17-77

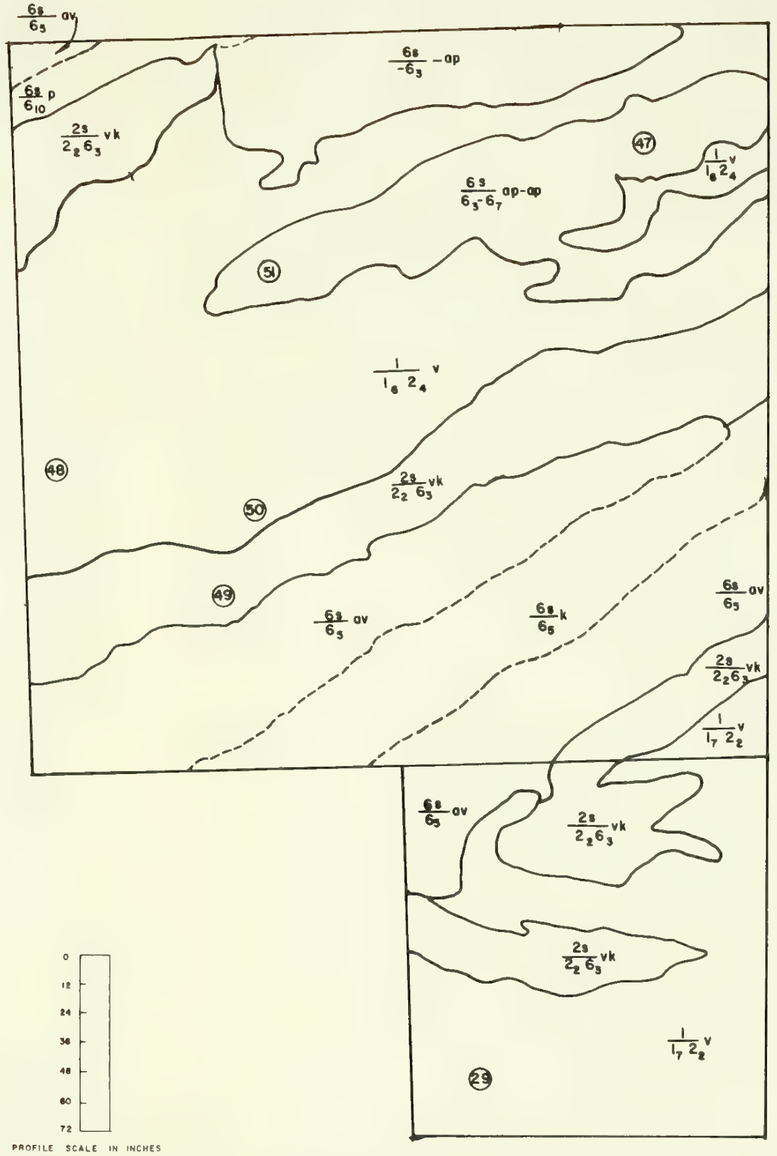
KIMBETO STUDY AREA - NEW MEXICO

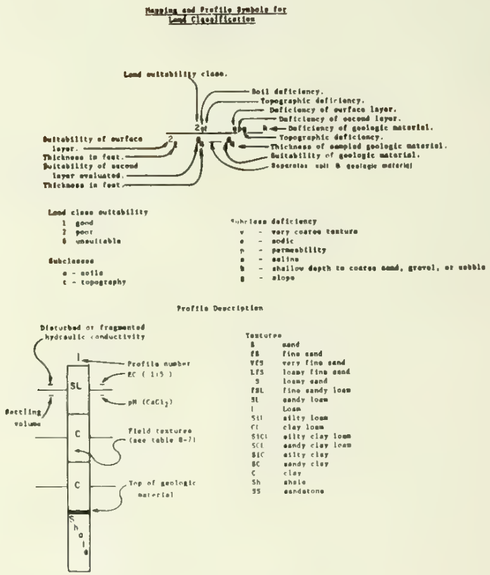
PROFILE DESCRIPTIONS AND LAND CLASSIFICATION *

DESIGNED	SUBMITTED
DRAWN	RECOMMENDED
TRACED	APPROVED
AMARILLO, TEXAS	FEBRUARY 1979

FIGURE No. Q-30


29
47
48
Location: 2150' S 1900' W NE cor Sec 27
Parent Material: Alluvium
Remarks: very gently rolling
0-13; granular, soft
13-36; granular, hvy salt**
36-65; single grain, vall hard
65-120; single grain, loose
Location: 850' S 1000' W NE cor Sec 32
Parent Material: Residual
Remarks: Long lan areas, spmy eapplan meander
0-4; granular, sand an sand
4-8; blocky, plastic, v stickhy
8-22; ot blocky, v plastic, stickhy
22-36; blocky, sli salt*
36-48; blocky plastic, v stickhy
48-60, massive, v hard
60-70; massive, plastic, v stickhy
70-130; massive, v hard
Location: 400' S 1200' W NE cor Sec 33
Parent Material: Alluvium
Remarks: mod lew anmle to S
0-10; granular, sli soft
10-24, granular, hard, vsli plastic
24-72, single grain, sli salt*
72-120; single grain, loose
49
50
51
NO LAB DATA
Location: 1430' E 1320' S NW cor Sec 22
Parent Material: Alluvium
Remarks: weathered shale exposed in spots
0-60; single grain, Loose
NO LAB DATA
Location: 1700' E 1950' S NW cor Sec 31
Parent Material: Alluvium
Remarks: very gentle slope to S
0-4; granular, soft
4-13; granular, sli hard, sli plastic and stickhy
13-48; granular, soft, hvy salt**
48+; single grain, loose
Location: 1080' S 1840' E NW cor Sec 32
Parent Material: Residual
Remarks: sl anmle
0-10; granular, soft, vsli plastic and sticky
10-29; blocky sli hard, hvy cal**
29-40; granular, vsli hard
40-72; massive, plastic, v sticky





LEGEND

$\frac{2s}{2_3 1_2 6_5}$ VS Land Class

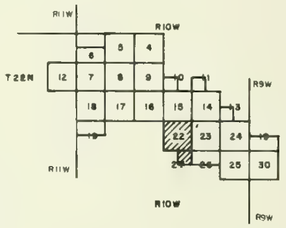
(3) PROFILES

—— Separates Classes

- - - - Separates Subclasses

LAND CLASS**	ACRES
1	361
2	136
Total	497
A	303
GRAND TOTAL	800

** For complete acreage of each individual land classification see table Q-2



* Lands were classified for their suitability as a source of planting media

900 0 500 1000
MAP SCALE IN FEET (Approximate)

ALWAYS THINK SAFETY

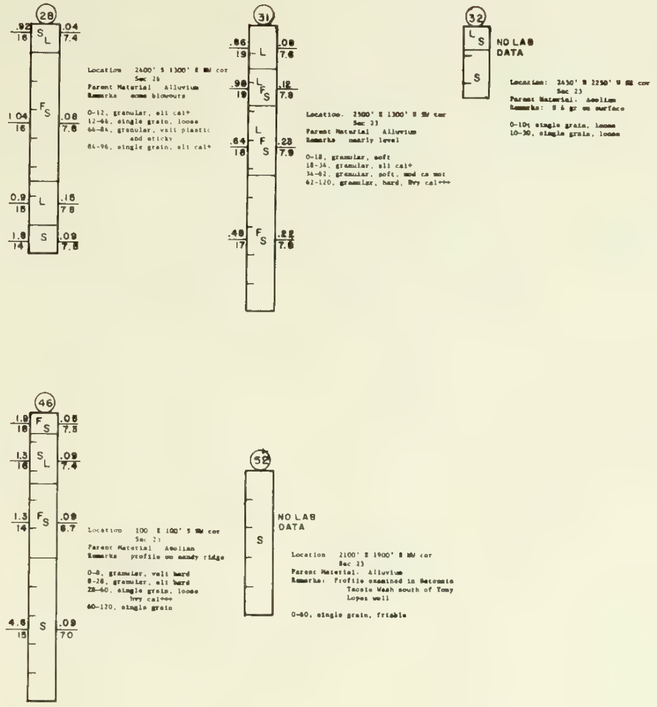
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

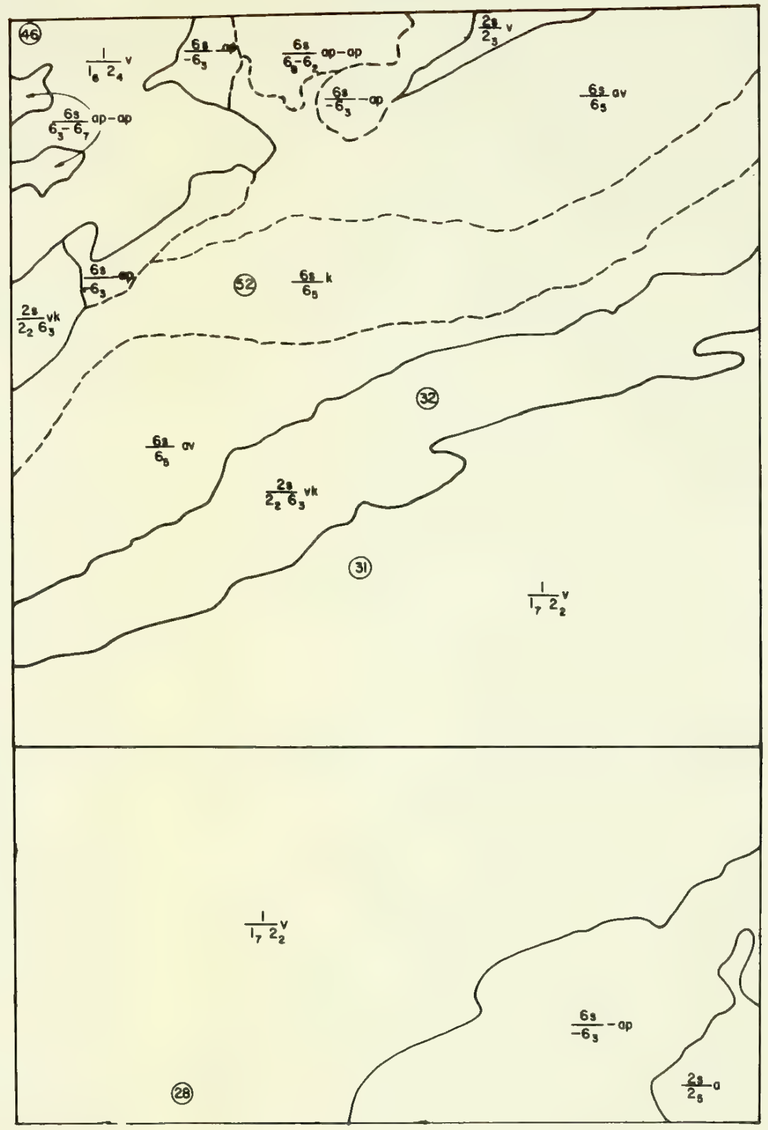
EMRIA REPORT NO. 17-77
KIMBETO STUDY AREA - NEW MEXICO

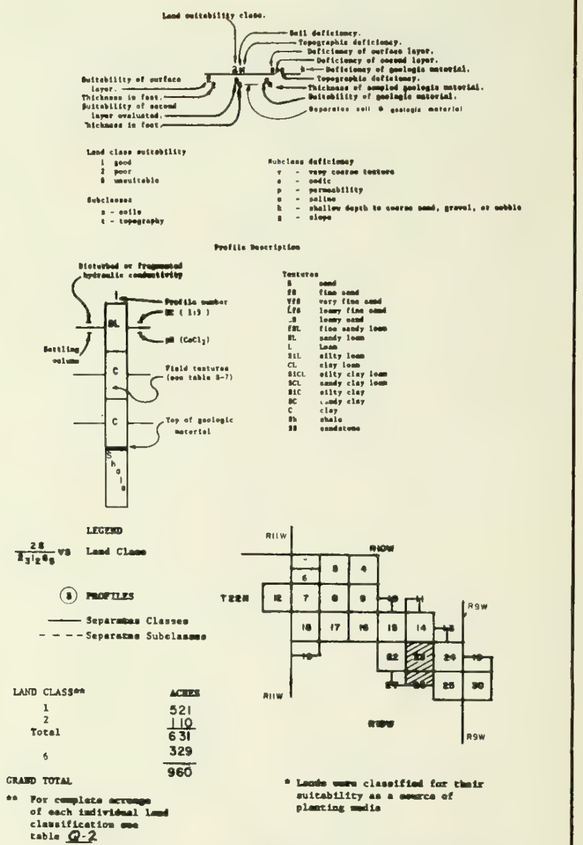
PROFILE DESCRIPTIONS AND LAND CLASSIFICATION *

DESIGNED	SUBMITTED
DRAWN	RECOMMENDED
CHECKED	APPROVED

FIGURE No. Q-31


28
.92 16 S L .04 7.4
1.04 16 F S .08 7.8
0.9 15 L .15 7.8
1.8 14 S .09 7.8
Location 2400' S 1300' E NW cor Sec 24
Parent Material Alluvium
Remarks some blowouts
0-12, granular, slt cal*
12-46, single grain, loose
46-84, granular, vsl plastic and sticky
84-96, single grain, slt cal*
31
.86 19 L .09 7.6
.90 19 L F S .18 7.8
.84 16 L S .23 7.9
.48 17 F S .22 7.6
Location 2500' E 1300' S NW cor Sec 23
Parent Material Alluvium
Remarks nearly level
0-18, granular, soft
18-34, granular, slt cal*
34-42, granular, soft, mod ca mat
42-120, granular, hard, Bvy cal**
32
L S S
NO LAB DATA
Location 3450' S 2250' W NE cor Sec 23
Parent Material Aeolian
Remarks: S h gr on surface
0-10+ single grain, loose
10-30, single grain, loose
46
1.8 18 F S .08 7.5
1.3 16 S L .09 7.4
1.3 16 F S .09 8.7
4.6 15 S .09 7.0
Location 100 E 100' S NW cor Sec 2)
Parent Material Aeolian
Remarks profile on sandy ridge
0-8, granular, vsl hard
8-28, granular, slt hard
28-60, single grain, loose Bvy cal**
60-120, single grain
32
S
NO LAB DATA
Location 2100' E 1900' S NW cor Sec 23
Parent Material Alluvium
Remarks: Profile examined in Barcomia Tarzia Wash south of Tony Lopez well
0-60, single grain, friable





0 12 24 36 48 60 72
PROFILE SCALE IN INCHES

500 0 500 1000
MAP SCALE IN FEET
(Approximate)

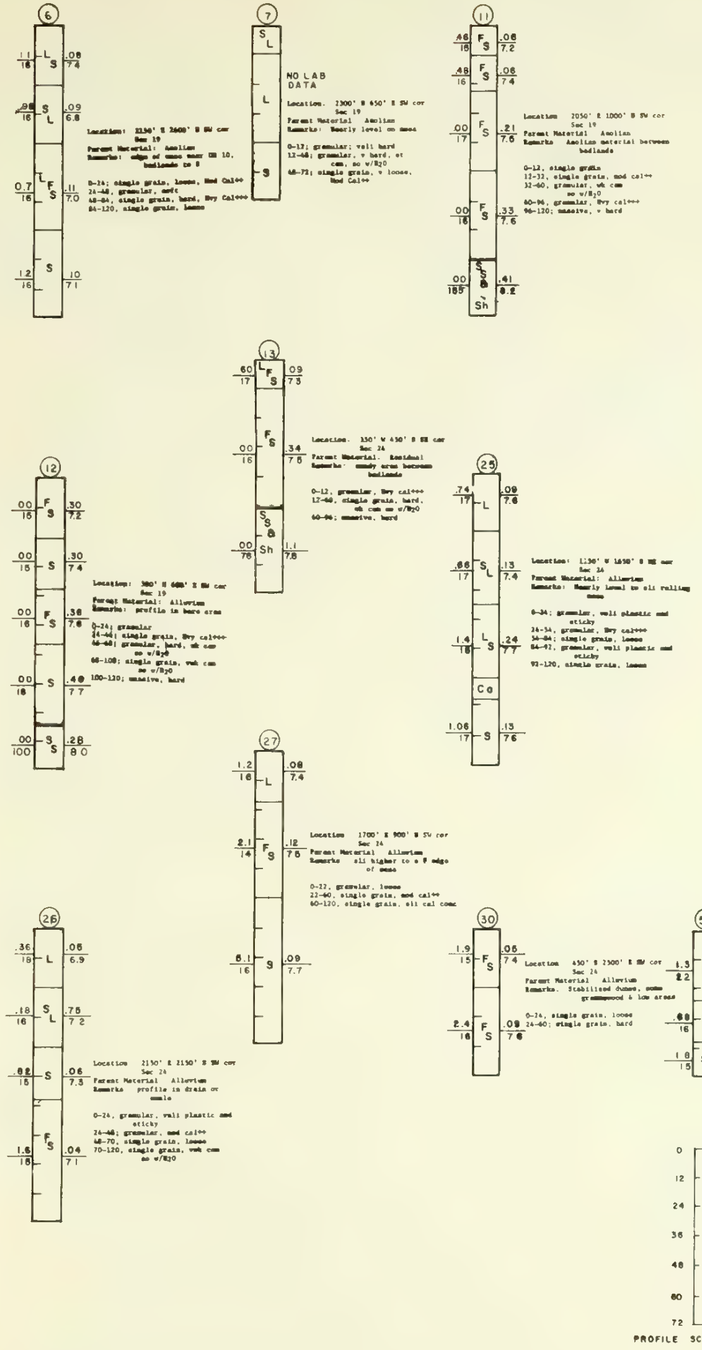
ALWAYS THINK SAFETY

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

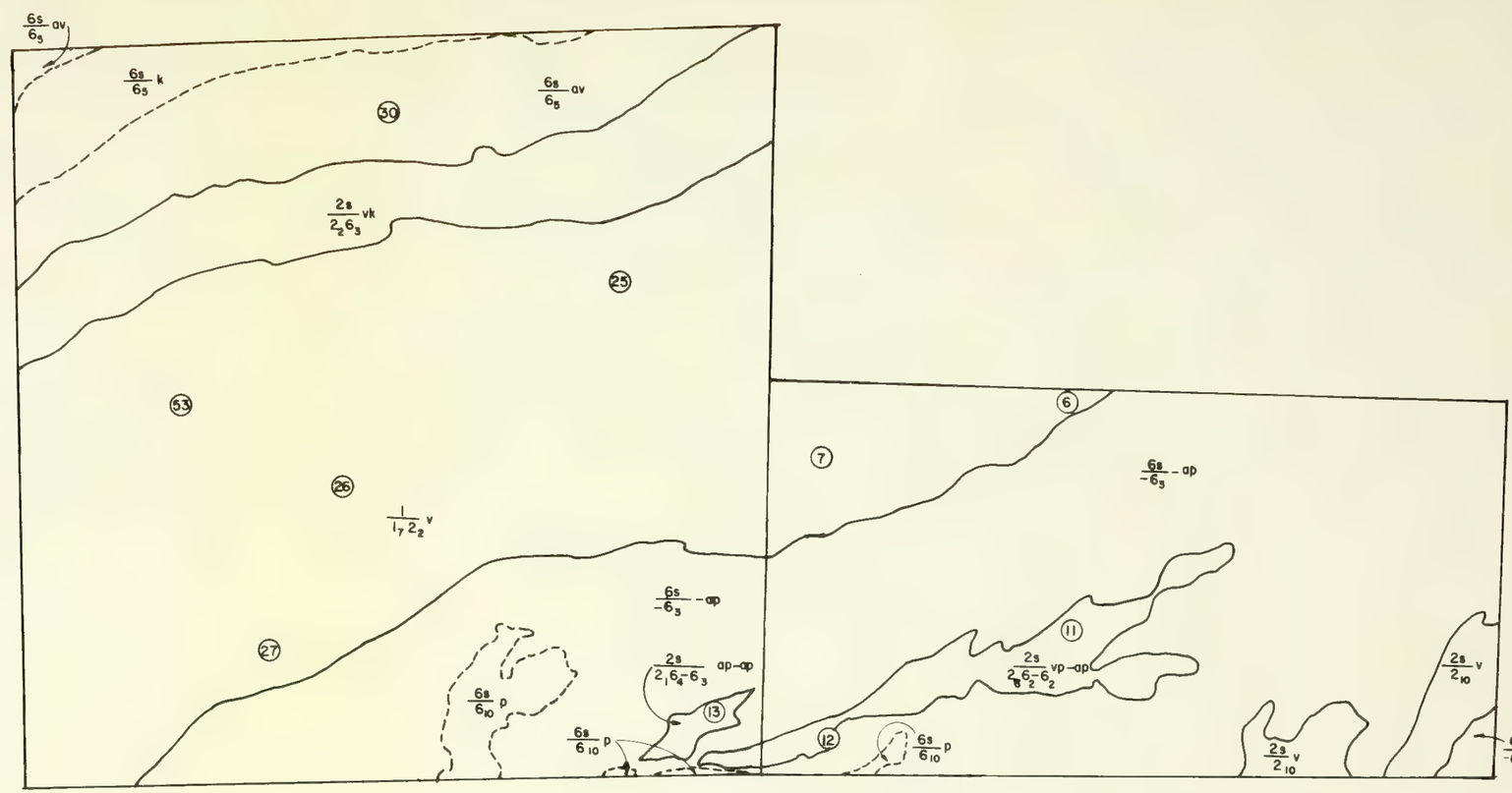
EMRIA REPORT NO. 17-77
KIMBETO STUDY AREA - NEW MEXICO
PROFILE DESCRIPTIONS AND LAND CLASSIFICATION*

DESIGNED ---- SUBMITTED ----
DRAWN ---- RECOMMENDED ----
CHECKED ---- APPROVED ----

AMARILLO, TEXAS FEB 1979 FIGURE No Q-32

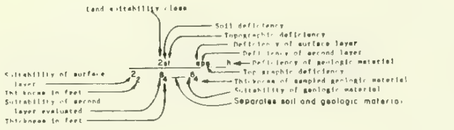

6
Location: 2136' S 2640' E SW cor Sec 19
Parent Material: Aeolian
Remarks: edge of mesa near CB 10, badlands to S
0-24; single grain, loose, mod Cal++
24-48, granular, soft
48-84, single grain, hard, Dry Cal+++
84-120, single grain, loose
7
NO LAB DATA
Location: 2300' N 650' E SW cor Sec 19
Parent Material: Aeolian
Remarks: Nearly level on mesa
0-17; granular; vsli hard
17-48; granular, v hard, et cem, no w/Bjo
48-72; single grain, v loose, Mod Cal++
11
Location 2050' E 1000' N SW cor Sec 19
Parent Material: Aeolian
Remarks: Aeolian material between badlands
0-13, single grain
13-32, single grain, mod cal++
32-60, granular, wk cem no w/Bjo
60-96, granular, Dry cal+++
96-120; massive, v hard
13
Location: 350' W 650' S NE cor Sec 24
Parent Material: Aeolian?
Remarks: sandy area between badlands
0-12, granular, Dry cal+++
12-60, single grain, hard, wk cem no w/Bjo
60-96; massive, hard
25
Location: 1150' W 1650' S NE cor Sec 24
Parent Material: Alluvium
Remarks: Nearly Level to sli rolling area
0-34; granular, vsli plastic and sticky
34-54, granular, Dry cal+++
54-84; single grain, loose
84-93, granular, vsli plastic and sticky
93-120, single grain, loose
12
Location: 380' N 660' E SW cor Sec 19
Parent Material: Alluvium
Remarks: profile in bare area
0-24; granular
24-44; single grain, Dry cal+++
44-68; granular, hard, wk cem no w/Bjo
68-108; single grain, vwk cem no w/Bjo
108-120; massive, hard
27
Location 1700' E 900' S SW cor Sec 24
Parent Material: Alluvium
Remarks: sli higher to e & S edge of mesa
0-22, granular, loose
22-60, single grain, mod cal++
60-120, single grain, sli cal conc
26
Location 2150' E 2150' S SW cor Sec 24
Parent Material: Alluvium
Remarks: profile in drain or swale
0-24, granular, vsli plastic and sticky
24-48; granular, mod cal++
48-70, single grain, loose
70-120, single grain, vwk cem no w/Bjo
30
Location 450' S 2500' E SW cor Sec 24
Parent Material: Alluvium
Remarks: Stabilized dunes, some grasswood & low areas
0-24, single grain, loose
24-60; single grain, hard
53
Location 2450' S 1100' E SW cor Sec 24
Parent Material: Alluvium
Remarks: nearly level on mesa
0-30, granular, vsli hard, vsli plastic
30-46, granular, mod cal++
46-60, single grain, sli loose

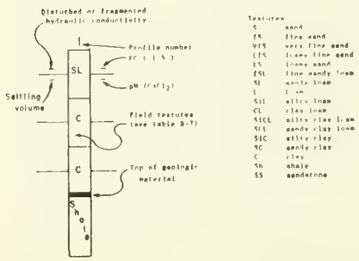
PROFILE SCALE IN INCHES



MAP SCALE IN FEET
(Approximate)

Mapping and Profile Symbols for Land Classification





LEGEND

2S/2 3 1 2 6 5 VS Land Class

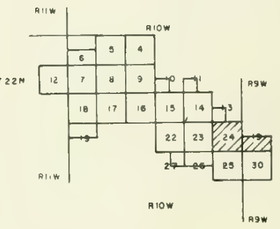
(3) PD FILES

Separates Classes

Separates Subclasses

LAND CLASS**	ACRES
1	367
2	120
Total	487
b	473
GRAND TOTAL	960

** For complete acreage of each individual land classification see table Q-2



* Lands were classified for their suitability as a source of planting media

ALWAYS THINK SAFETY

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

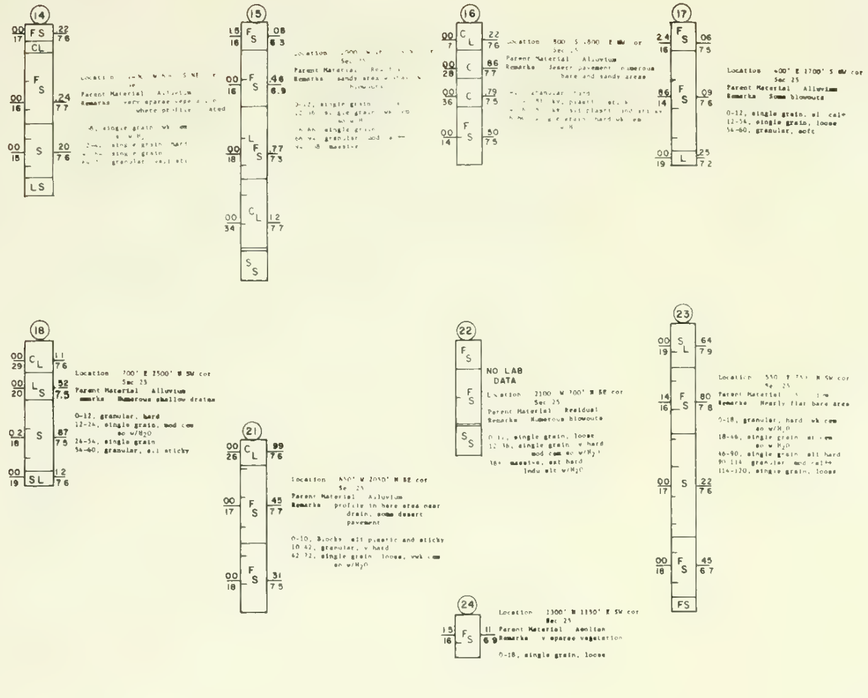
EMRIA REPORT NO 17 77

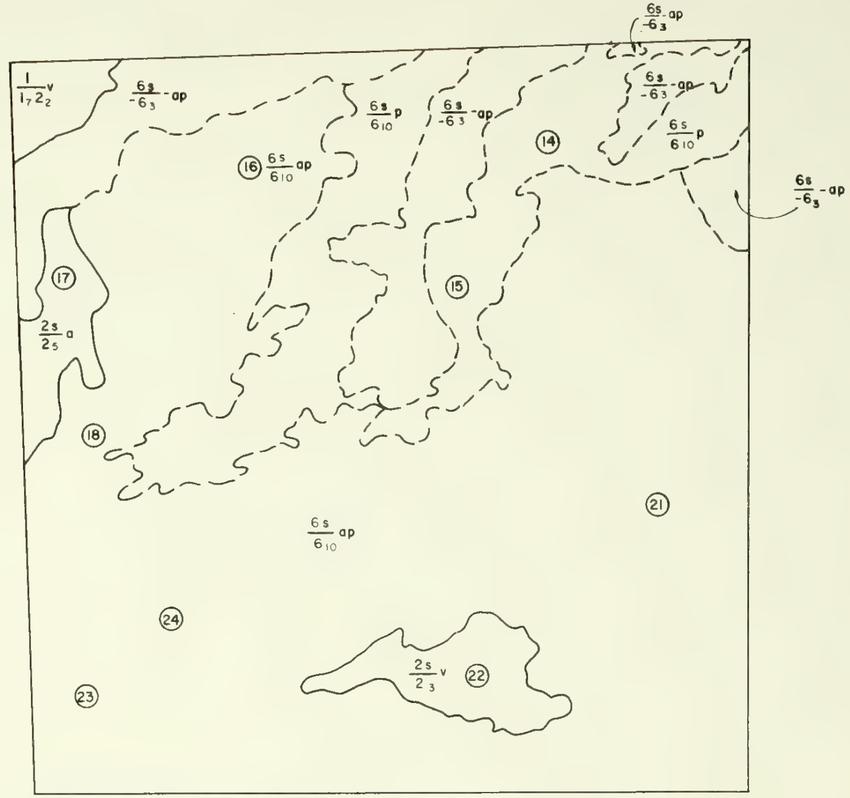
KIMBETO STUDY AREA - NEW MEXICO

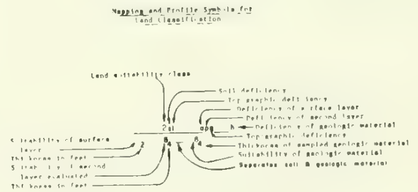
PROFILE DESCRIPTIONS AND LAND CLASSIFICATION*

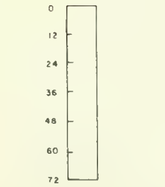
DESIGNED	SUBMITTED
DRAWN	RECOMMENDED
TRACED	APPROVED
AMARILLO, TEXAS	FEBRUARY 1979

FIGURE No. Q-33









LEGEND

$\frac{2S}{2_3 2_6 5}$ VS Land Class

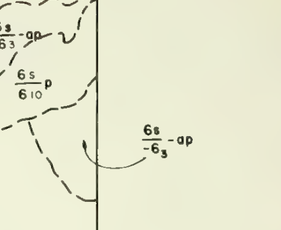
(3) PROFILES

——— Separates Classes

– – – – Separates Subclasses

LAND CLASS**	ACRES
1	9
2	33
Total	42
*	598
GRAND TOTAL	640

** For complete acreage of each individual land classification see table Q-2



* Lands were classified for their suitability as a source of planting media

ALWAYS THINK SAFETY

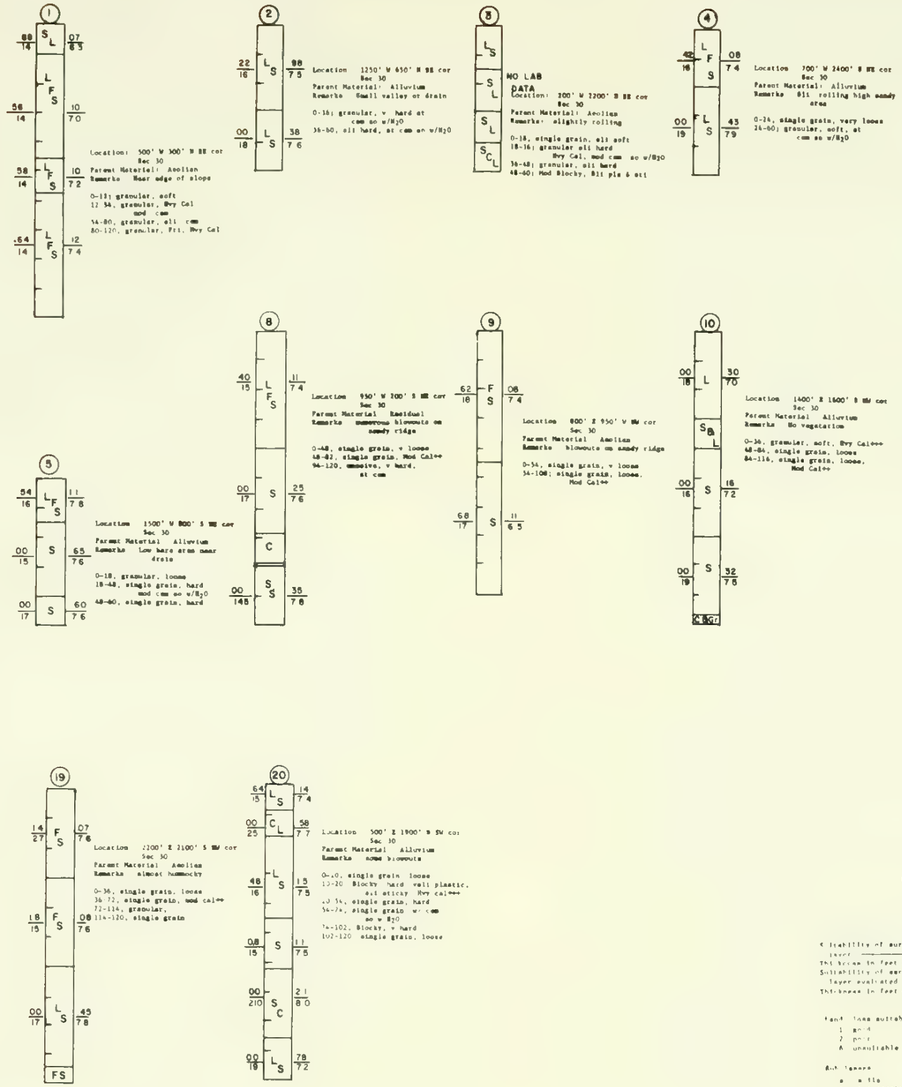
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

EMRIA REPORT NO 17-77
KIMBETO STUDY AREA - NEW MEXICO

PROFILE DESCRIPTIONS AND LAND CLASSIFICATION*

DESIGNED	SUBMITTED
DRAWN	RECOMMENDED
CHECKED	APPROVED
AMARILLO, TEXAS	FEBRUARY 1979

FIGURE No Q-34


1
Location: 500' W 300' N SE cor Sec 30
Parent Material: Aeolian
Remarks: Near edge of slope
0-12, granular, soft
12-54, granular, Dry Cal mod ⟨cem
54-80, granular, sli ⟨cem
80-120, granular, Fri, Dwy Cal
2
Location 1250' W 650' N SE cor Sec 30
Parent Material: Alluvium
Remarks: Small valley or drain
0-18; granular, v hard at ⟨cem so w/H2O
18-50, sli hard, at ⟨cem so w/H2O
3
NO LAB DATA
Location: 300' W 2200' N SE cor Sec 30
Parent Material: Aeolian
Remarks: slightly rolling
0-18, single grain, sli soft
18-36; granular sli hard Dry Cal, mod ⟨cem so w/H2O
36-48; granular, sli hard
48-60; Mod Blocky, Sli pla & sct
4
Location 700' W 2400' N SE cor Sec 30
Parent Material: Alluvium
Remarks: Sli rolling high sandy area
0-24, single grain, very loose
24-60; granular, soft, at ⟨cem so w/H2O
5
Location 1500' W 800' S NE cor Sec 30
Parent Material: Alluvium
Remarks: Low bare area near drain
0-18, granular, loose
18-48, single grain, hard mod ⟨cem so w/H2O
48-80, single grain, hard
8
Location 950' W 700' S NE cor Sec 30
Parent Material: Residual
Remarks: numerous blowouts on sandy ridge
0-48, single grain, v loose
48-82, single grain, Mod Calc⇔
94-120, massive, v hard, at ⟨cem
9
Location 800' E 950' W NW cor Sec 30
Parent Material: Aeolian
Remarks: blowouts on sandy ridge
0-34, single grain, v loose
34-108; single grain, loose, Mod Calc⇔
10
Location 1400' E 1600' S NW cor Sec 30
Parent Material: Alluvium
Remarks: No vegetation
0-36, granular, soft, Dry Calc⇔
48-84, single grain, Loose
84-116, single grain, loose, Mod Calc⇔
19
Location 2200' E 2100' S NW cor Sec 30
Parent Material: Aeolian
Remarks: Almost hummocky
0-36, single grain, loose
36-72, single grain, mod calc⇔
72-114, granular, 114-120, single grain
20
Location 500' E 1900' S SW cor Sec 30
Parent Material: Alluvium
Remarks: some hummocks
0-40, single grain loose
40-120 Blocky hard soil plastic, sl sticky Dry calc⇔
0-34, single grain, hard
34-74, single grain w/⟨cem so w H2O
74-102, Blocky, v hard
102-120 single grain, loose
500 0 500 1000
MAP SCALE IN FEET (Approximate)
Mapping and Profile Symbols for Land Classification
Land suitability class
Soil deficiency
Topographic deficiency
Deficiency of surface layer
Deficiency of second layer
Deficiency of geologic material
Topographic deficiency
Thickness of sampled geologic material
Suitability of geologic material
Separates soil & geologic material
Suitability of surface layer
Thickness in feet
Suitability of second layer evaluated
Thickness in feet
Land suitability
1 good
2 poor
3 unsuitable
Soil texture
Topography
Soil deficiency
v - very - coarse texture
s - stony
x - unsuitable
w - wetness
b - shallow depth to coarse sand, gravel or cobble
g - salt
Profile Description
Plasticity or fragmental
Moisture, conductivity
Profile number
Color (dry)
pH (Field)
Soil texture (see table B-7)
Top of geologic material
Shale
Cutting volume
Texture
S sand
fS fine sand
VFS very fine sand
LFS loamy fine sand
LS loamy sand
FSL fine sandy loam
SL sandy loam
L loam
SiL silty loam
CL clay loam
SiCL silty clay loam
SCL sandy clay loam
SiC silty clay
SC sandy clay
C clay
Sh shale
SS sandstone
0 2 24 36 48 60 72
PROFILE SCALE IN INCHES
LEGEND
2S/2,3,6S VS Land Class
(3) Profiles
Separates Classes
Separates Subclasses
LAND CLASS** ACRES
1 69
2 159
Total 228
h 412
GRAND TOTAL 640
** For complete acreage of each individual land classification see table Q-2
R11W R10W R9W T22N
* Lands were classified for their suitability as a source of planting media
ALWAYS THINK SAFETY
UNITED STATES DEPARTMENT OF THE INTERIOR BUREAU OF RECLAMATION
EMRIA REPORT NO 17-77
KIMBETO STUDY AREA - NEW MEXICO
PROFILE DESCRIPTIONS AND LAND CLASSIFICATION *
DESIGNED SUBMITTED
DRAWN RECOMMENDED
CHECKED APPROVED
AMARILLO, TEXAS FEBRUARY 1979
FIGURE No Q-35

Taxonomic Classification of Soils

Soils are classified so that the significant soil characteristics can be remembered. Classification is an assemblage of knowledge about soils and their relationships to one another and to the whole environment. Classification facilitates the development of principles that help in the understanding of the behavior of soils and their response to manipulation. Through classification and then through use of soil maps, the knowledge of soils can be applied to specific tracts of land.

The narrow categories of classification allow the application of soil knowledge to the management of range, watershed, woodland, wildlife, mined-land reclamation, and other engineering works.

The classification system has six categories. Beginning with the broadest, the categories are order, suborder, great group, subgroup, family, and series. In this system, the criteria used as a basis for classification are soil properties that are observable and measurable. The properties are chosen, however, so that soils of similar genesis, or mode of origin, are grouped. In table Q-3 the major soil series at the study area are places in the classification system. For further information about the system see Soil Taxonomy, USDA-SCS Agriculatural Handbook No. 436, 1975.

Soil Inventory

A soil inventory was conducted to obtain basic soil and environmental data. This will enable limited prediction of soil behavior and projection of soil information outside the study area.

To facilitate the inventory, nine soil mapping units were delineated (figures Q-36 and Q-37) with assistance fron the Soil Conservation Service (SCS) at Aztec, New Mexico. For the EMRIA program within the State of New Mexico, such soil mapping units are numbered for ease in identification starting at 7001 and running consecutively for each new soil unit thereafter. For the first EMRIA study in New Mexico (Bisti West--Report 5-1976), units were numbered from 7001-7011. For the Kimbeto study (the second EMRIA study in New Mexico), some of the same soil units were found plus those numbered to 7015.

Soil mapping units are not the equivalent of individual soil series but are soils (grouped together to form a unit) consisting of similar or contrasting characteristics. The major soil series at the Kimbeto study area are Doak, Shiprock, Sheppard, Nageesi*/, Blancot, Notal, Stumble, Turley, Huerfano, Muff, and Uffens. Table Q-3 gives the taxonomy of these soil series and table Q-4 gives a real extent of the units. Minor series, types, phases, and variations occur throughout the study area but are counted as inclusions of the major series.

*/ The Nageesi series has been renamed Avalon by SCS, but preparation of this report was too advanced to incorporate the name change.

Table Q-3
Taxonomy of Soil Series at the Kimbeto Study Area

Series	Family	Subgroup	Order
Doak	Fine-loamy, mixed, mesic	Typic Haplargids	Aridisols
Huerfano	Clayey, mixed, mesic, shallow	Typic Natrargids	Aridisols
Notal	Fine, mixed, mesic	Typic Camborthids	Aridisols
Sheppard	Mixed, mesic	Typic Torrepsamments	Entisols
Shiprock	Coarse-loamy, mixed, mesic	Typic Haplargids	Aridisols
Stumble	Mixed, mesic	Typic Torrepsamments	Entisols
Uffens	Fine-loamy, mixed, mesic	Typic Natrargids	Aridisols
Nageesi	Coarse-loamy, mixed, mesic	Typic Calciorthid	Aridisols
Fruitland	Coarse-loamy, mixed, (Calcareous), mesic	Typic Torriorthent	Entisols
Persayo	Loamy, mixed (Calcareous), mesic, shallow	Typic Torriorthent	Entisols
Blancot	Fine-loamy, mixed, mesic	Typic Haplargids	Aridisols
Turley	Fine-loamy, mixed (Calcareous), mesic	Typic Torriorthent	Entisols
Farb	Wavy, mixed (Calcareous)	Lithic Torriorthent	Entisols
Muff	Fine-loamy, mixed, mesic	Typic Haplargids	Aridisols

Table Q-4

Soil Association Mapping units Acreages

	Section / UNITS	12	4	5	6	7	8	9	10	11	13	14	15	16	17	18	19	22	23	24	25	26	27	29	30	Total per unit
R3	BADLANDS	597	640	630	310	568	608	445	43	2	13	337	58	177	57		221	40		88	68	57		240	175	6,374
19E	Dozk - Shiprock - Sheppard Association	40		10	10					131	1	137	66					300	298	348	6	257	92	36	78	1,810
19D	Dozk - Nageezi Association							195	30					234	440	194	91									1,184
16E	Blancot - Notal Association								77		15		17	169				205	114				67			664
40M	Stumble - Turley - Notal Association										116	166	227						71	30	566	6		44	374	1,600
09H	Huerfano - Muff - Ustorthents complex	3				72	32								143	446	8									704
R13	Riverwash (Fluvents)								10	7	15		64	48				88	97	24			1			354
R14	Fruitland - Persayo - Sheppard complex									20									60	150					13	243
R22	Dunelands												208	12				7								227
	Total per section	640	640	640	320	640	640	640	160	160	160	640	640	640	640	640	320	640	640	640	640	320	160	320	640	12,160

The following additional soils information may be found at the end of section Q (detailed Soil Inventory tables): Soil Survey Interpretations (table Q-12), Point Site Land Characterization (table Q-13), Determination of Erosion Condition Class (table Q-14), and Vegetation-Soil Description (table Q-15).

Located in the soil mapping units of the Kimbeto study area are master sites (see figures Q-36 and Q-37). These master sites represent a profile of the dominant soil series (phase or variation) of a given unit. Complete descriptions, locations, and other pertinent data for all master sites are given in tables Q-10, Q-11, Q-13, Q-14, and Q-15. The soil mapping units (SMU) are described below.

SMU 7001 - R22 - Duneland, 227 acres - 1.87 percent of study area

These soils are deep, somewhat excessively drained, almost barren areas of sand-sized particles drifted and piled up by the wind. No soil horizons have developed. They are usually elongated in the direction of the prevailing winds and occupy hills, ridges, blownout areas, and mesa tops.

Permeability is very rapid, and available water holding capacity (AWHC) is very low. Organic matter (O.M.) is almost zero, and natural fertility is very low. Erosion class is critical with no surface runoff. There is little to no vegetative cover.

Inclusions are less than 5 percent, and the dominant series is Sheppard.

Due to the instability of this soil because of high wind erosion hazard, it is unsuitable as a planting media. This is in addition to the low AWHC and coarse textures.

SMU 7002 - R3 - Badlands, 5,374 acres - 44.19 percent of study area

This is a miscellaneous area of steep to very steep, nonstony barren land, dissected by many intermittent drainage channels entrenched in soft shale. Local relief varies from 25 to 500 feet. Sediment potentials are high due to the high surface runoff and active geological erosion taking place in these areas. This soil mapping unit occupies upland canyons, valleys, ridges, hills, and breaks.

Permeability is very slow, and AWHC is very low. This land type has a shallow root depth, is low in natural fertility and O.M. content.

Native vegetation is sparse if it exists at all. Some alkali sacaton, shadscale, or Russian thistle can be found in isolated areas.

Badland areas are unsuitable as a source of planting media because of the high saline and/or sodic condition of the geologic material.

Huerfano, Stumble, Sheppard, Uffens, and Turley, and various phases of Turley, Sheppard, and Stumble occur as inclusions in this land type. These inclusions make up less than 15 percent of the SMU.

T23N
T22N
R11W
R10W

6 5 4

12 (62) 7 8 9

18 17 (80) 16 (58)

19

MATCH LINE TO FIGURE Q-37

N

2000 0 2000
SCALE OF FEET

NOTE:
FOR EXPLANATION OF SYMBOLS
SEE FIGURE Q-37

ALWAYS THINK SAFETY

UNITED STATES
DEPARTMENT OF THE INTERIOR
WATER AND POWER RESOURCES SERVICE
EMRIA REPORT NO. 17-77
KIMBETO STUDY AREA - NEW MEXICO

SOIL MAPPING UNITS

DESIGNED _____ SUBMITTED _____
DRAWN _____ RECOMMENDED _____
CHECKED _____ APPROVED _____
AMARILLO, TEX JAN. 1978

FIG. Q-36

The following additional soils information may be found at the end of section Q (detailed Soil Inventory tables): Soil Survey Interpretations (table Q-12), Point Site Land Characterization (table Q-13), Determination of Erosion Condition Class (table Q-14), and Vegetation-Soil Description (table Q-15).

Located in the soil mapping units of the Kimbeto study area are master sites (see figures Q-36 and Q-37). These master sites represent a profile of the dominant soil series (phase or variation) of a given unit. Complete descriptions, locations, and other pertinent data for all master sites are given in tables Q-10, Q-11, Q-13, Q-14, and Q-15. The soil mapping units (SMU) are described below.

SMU 7001 - R22 - Duneland, 227 acres - 1.87 percent of study area

These soils are deep, somewhat excessively drained, almost barren areas of sand-sized particles drifted and piled up by the wind. No soil horizons have developed. They are usually elongated in the direction of the prevailing winds and occupy hills, ridges, blownout areas, and mesa tops.

Permeability is very rapid, and available water holding capacity (AWHC) is very low. Organic matter (O.M.) is almost zero, and natural fertility is very low. Erosion class is critical with no surface runoff. There is little to no vegetative cover.

Inclusions are less than 5 percent, and the dominant series is Sheppard.

Due to the instability of this soil because of high wind erosion hazard, it is unsuitable as a planting media. This is in addition to the low AWHC and coarse textures.

SMU 7002 - R3 - Badlands, 5,374 acres - 44.19 percent of study area

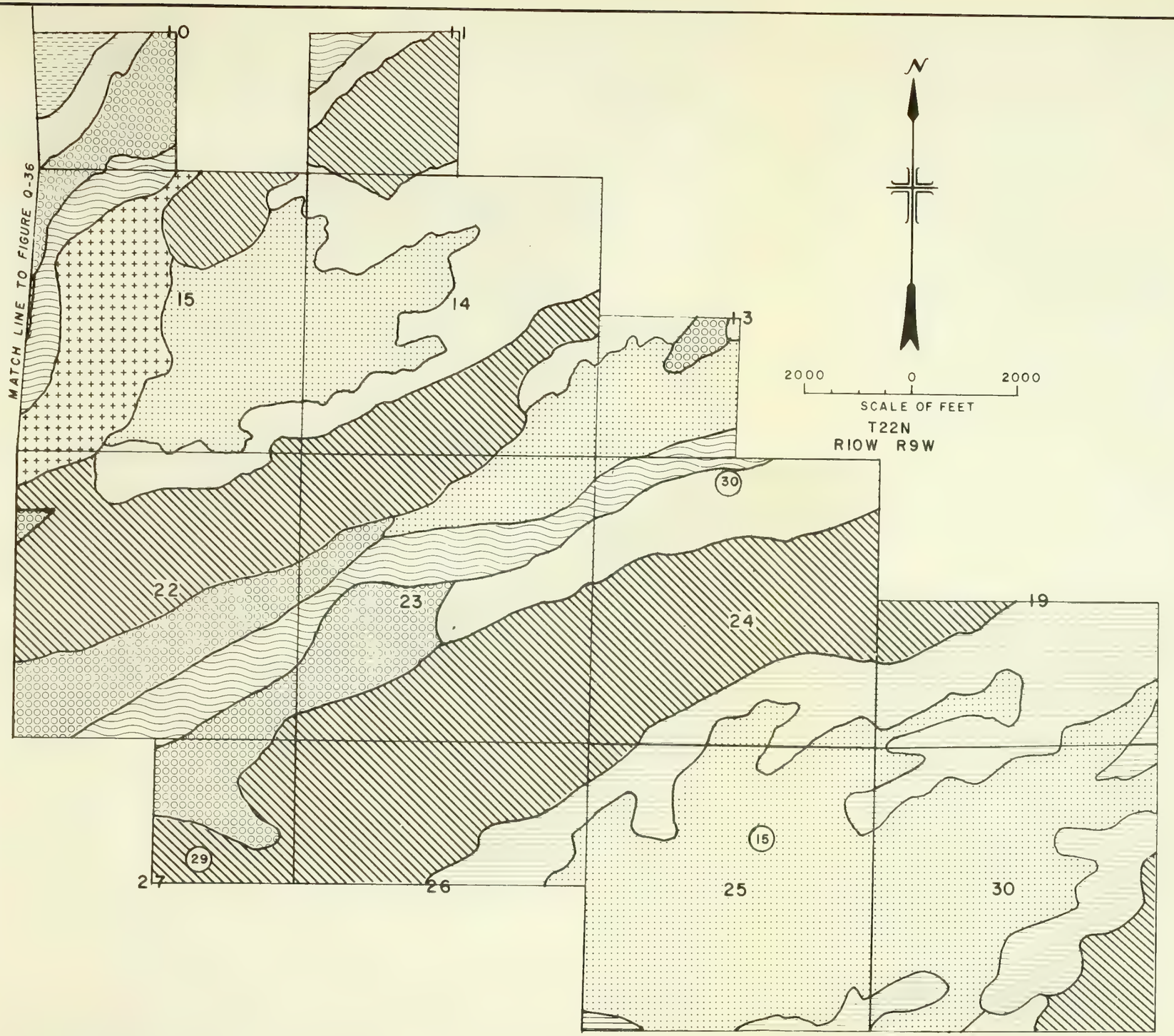
This is a miscellaneous area of steep to very steep, nonstony barren land, dissected by many intermittent drainage channels entrenched in soft shale. Local relief varies from 25 to 500 feet. Sediment potentials are high due to the high surface runoff and active geological erosion taking place in these areas. This soil mapping unit occupies upland canyons, valleys, ridges, hills, and breaks.

Permeability is very slow, and AWHC is very low. This land type has a shallow root depth, is low in natural fertility and O.M. content.

Native vegetation is sparse if it exists at all. Some alkali sacaton, shadscale, or Russian thistle can be found in isolated areas.

Badland areas are unsuitable as a source of planting media because of the high saline and/or sodic condition of the geologic material.

Huerfano, Stumble, Sheppard, Uffens, and Turley, and various phases of Turley, Sheppard, and Stumble occur as inclusions in this land type. These inclusions make up less than 15 percent of the SMU.



EXPLANATION:

19E - DOAK - SHIPROCK - SHEPPARD ASSOCIATION, ROLLING — 1,810 acres, 14.88 %
7004

19D - DOAK - NAGEESI ASSOCIATION, GENTLY SLOPING - 1,184 acres, 9.74 %
7012

16C - BLANCOT - NOTAL ASSOCIATION, GENTLY SLOPING - 664 acres, 5.46 %
7013

40M - STUMBLE - TURLEY - NOTAL ASSOCIATION
7010 1,600 acres, 13.16 %

09H - HUERFANO - MUFF - UFFENS COMPLEX, GENTLY ROLLING - 704 acres, 5.79 %
7014

R3 - BADLANDS
7002 5,374 acres, 44.19 %

R13 - RIVERWASH (FLUVENTS) FREQUENTLY FLOODED, 0.1% SLOPES - 354 acres, 2.91 %
7005

R14 - FRUITLAND - PERSAYO - SHEPPARD COMPLEX, HILLY, 243 acres, 2.00 %
7015

R22 - DUNELAND
227 acres, 1.81 %
7001

(15) MASTER SITE LOCATIONS

ALWAYS THINK SAFETY

UNITED STATES
DEPARTMENT OF THE INTERIOR
WATER AND POWER RESOURCES SERVICE
EMRIA REPORT NO. 17-77
KIMBETO STUDY AREA - NEW MEXICO

SOIL MAPPING UNITS

DESIGNED _____ SUBMITTED _____
DRAWN _____ RECOMMENDED _____
CHECKED _____ APPROVED _____
AMARILLO, TEX. JAN. 1979

FIG. Q-37

SMU 7004 - 19E - Doak-Shiprock-Sheppard-Mayqueen Association, rolling, 1,810 acres - 14.88 percent of study area

This mapping unit consists of well to excessively drained soils that occur in a regular and repeating pattern. These lands are wind oriented sand dunes associated with broad depressions on mesa tops and sandy ridges. The nearly level Doak soils occupy the lower depressions; the gently sloping Shiprock soils occupy intermediate slopes; and the rolling Sheppard and Mayqueen soils occupy dunelands.

Doak soils, 40 percent of the association, typically have a surface layer which is brown-loose-loamy-fine sand about 6 inches thick. The upper subsoil is brownish-gray, hard clay loam about 22 inches thick; the lower subsoil is light reddish-brown, hard clay loam about 10 inches thick; the upper substratum is light reddish-brown sandy loam, about 10 inches thick; the lower substratum is stratified, grayish-brown clay loam, pale brown loamy sand, and light yellowish-brown loam to a depth of 120 inches.

Permeability is moderately slow, AWHC is high, effective rooting depth is 60 inches, surface runoff is slow, O.M. is low, natural fertility is moderate.

Native vegetation consists of galleta, prickly pear, blue grama, broom snakeweed, sand dropseed, four-wing saltbush, yucca, and Indian ricegrass.

Shiprock soils, 20 percent of the association, typically have a surface layer which is pale brown loose loamy sand about 12 inches thick. The upper substratum is light yellowish-brown and brown sandy loam with $CaCO_3$ nodules about 24 inches thick. The middle substratum is light yellowish-brown loamy sand about 32 inches thick; the lower substratum is pale brown loose sand to a depth of 120 inches.

Permeability is moderately high, AWHC is moderate, effective rooting depth is 60 inches, O.M. is low, and natural fertility is medium.

Native vegetation includes most species found on Doak soils along with ring muhly, mormontea, and big sagebrush.

Sheppard and Mayqueen soils, 30 percent of the association, occur as a complex. Typically, in the Sheppard soil the surface layer is light yellowish-brown loose fine sand about 12 inches thick. The upper substratum is light yellowish-brown loose to slightly compact fine sand about 72 inches thick; the middle substratum is pale brown slightly compact loamy fine sand about 24 inches thick; the lower substratum is grayish-brown hard sandy clay to a depth of 120 inches.

Mayqueen typically has a surface layer which is brown loose loamy fine sand 3 inches thick. The upper subsoil is brown fine sandy loam about 9 inches thick. The lower subsoil is light yellowish-brown stratified loamy fine sand and fine sand to a depth of 60 inches.

Permeability is very rapid, AWHC is low, effective rooting depth is 60 inches, O.M. is low, natural fertility is low, and surface runoff is zero.

Native vegetation includes needle and thread, Indian ricegrass, ring muhly, spiny muhly, sand dropseed, Russian thistle, sand sagebrush, mormontea, and broom snakeweed.

All soils in this association are used for range and wildlife purposes. Regarding their use as planting media: Doak is good, notwithstanding low strength, moderate shrink-swell potential, and moderate erosion hazard; Shiprock is good but, because of moderately coarse textures and AWHC, it should be mixed with better soils; Sheppard and Mayqueen are fair because of coarse textures, low AWHC, high erosion hazard, and saline and sodic conditions in some areas.

Inclusions make up 10 percent of this association, having Moniereo and Turley occurring on protruding knolls and along narrow drainageways.

SMU 7005 - R13 - Riverwash (Fluvents), frequently flooded (0 to 1 percent slope), 354 acres - 2.91 percent of study area

Riverwash soils (or fluvents) are not individual soils, but are many closely related soils; therefore, it is not practical to separate them into individual series. Their taxonomic classification is at the suborder; their textural family is given below. As the name implies, these soils are found in stream channels and are frequently flooded.

Typically, textures cover a wide range, and profiles are variable. Sand and gravel are dominant, with textures of the sandy or sandy skeletal family. Colors are variable and insignificant.

Permeability is rapid. Soils are often flooded when local storms produce enough moisture for runoff.

Vegetation occurs only on islands and stream margins due to the movement of water and abrasive action of sediment in the stream channel. Saltcedar, alkali sacaton, greasewood, and shadscale are the most commonly found species.

Riverwash soils are poor as planting media due to the instability and coarse texture of the soils.

SMU 7010 - 40M - Stumble-Turley-Notal Association, 1,600 acres - 13.16 percent of study area

This mapping unit consists of deep, generally poorly drained, coarse, moderately fine, and fine textured alluvian. Soils of this unit occupy alluvial fans and flood plains.

Stumble soils, 30 percent of the association, have a surface layer of light yellowish-brown loamy fine sand about 12 inches thick. The upper stratum is

light brown stratified loamy sand and fine sand 88 inches thick; the lower substratum is dark brown and brown silty clay to a depth of 120 inches.

Permeability is very low to zero due to high sodic conditions. AWHC is low, O.M. and natural fertility are low, erosion hazard is severe, and surface runoff is high.

Native vegetation consists of big sagebrush, galleta, broom snakeweed, cheatgrass, rubber rabbitbrush, shadscale, Russian thistle, four-wing saltbrush, and alkali sacaton. This vegetation represents less than 10 percent of the mapping unit since most vegetation is found on coppice mounds, depressions, or filled rills.

Turley soils, 25 percent of the association, are somewhat poorly drained. A typical surface layer is brown clay about 12 inches thick. The upper substratum is stratified, light brownish-gray clay loam and pale brown silt loam about 36 inches thick; the lower substratum is pale brown fine sand to a depth of 120 inches.

Permeability is very slow, effective rooting depth is 12 inches, AWHC is low, O.M. and natural fertility are low, and surface runoff is rapid.

Native vegetation is similar to that of the Stumble series and represents less than 10 percent of the mapping unit. Galleta, Russian thistle, alkali sacaton, and rubber rabbitbrush are found on coppice mounds, depressions, or filled rills.

The Notal series, described below under soil mapping unit 7013, makes up 25 percent of this association.

The entire association is unsuitable as planting media due to high saline and sodic conditions, very slow permeability, and AWHC of nearly zero.

Inclusions make up 20 percent of the association. Some of the series found are: Blancot, Azfield, Fruitland, Sheppard, and various phases of Turley, Stumble, and Notal.

SMU 7012 - 19D - Doak-Nageesi Association, gently sloping, 1,184 acres - 9.74 percent of study area

This association is similar to mapping unit 7004 in that it consists of well-drained soils that occur in a regular and repeating pattern. The landscape features mesas and mesa tops with the nearly level Doak located on the low mesa landscapes and the gently sloping Nageesi occupying landscapes just above the Doak soil.

The Doak series makes up about 50 percent of the association and is described under mapping unit 7004.

The well-drained Nagessi soils occupy 35 percent of the association. Typically, the surface layer is a brown loam about 8 inches thick. The subsoil consists of a strong brown loam about 10 inches thick which is strongly calcareous. The upper substratum is yellowish-red loam and also strongly calcareous; the lower substratum is below 40 inches and is a light yellowish-brown very fine sandy loam to 60 inches or more.

Permeability is slow, AWHC is high, and alkalinity is moderate to strong.

Native vegetation includes four-wing saltbush, Indian ricegrass, small soapweed, winterfat, mormontea, broom snakeweed, and galleta.

Most areas of this association are used for rangeland. As a planting media, Nagessi soils are fair because of slow permeability, low strength, high clay content, shrink-swell potential, and occasional high calcareousness or strong alkalinity.

Inclusions make up about 15 percent of the association. Shiprock is the dominant inclusion, but Farb and Persayo also occur along the mesa breaks.

SMU 7013 - 16C - Blancot-Notal Association, gently sloping, 664 acres - 5.46 percent of study area

This mapping unit consists of well drained to moderately well drained soils occurring in a regular, repetitive pattern. It is found in upland valley bottoms and drainage ways and valley filling side slopes. Blancot soils occupy upland valleys and alluvial fans, while Notal soils occupy the nearby level valley bottoms.

Blancot soils, 50 to 60 percent of the association, are well drained. The typical surface layer is brown to grayish-brown loam to a depth of 7 inches. Subsoils are brown to light brownish-gray clay loam to a depth of 16 inches. The substrata is grayish-brown to light grayish-brown loams or sandy clay loams to a depth of 40 inches or more.

Permeability is moderate to moderately slow, AWHC is high, natural fertility is low, and alkalinity is moderate to strong.

Native vegetation consists of galleta, big sagebrush, cheatgrass, and alkali sacaton.

Notal soils, 20 to 30 percent of the association, are moderately well drained. The surface layer is grayish-brown clay loam to a depth of 3 inches. Subsoil is grayish-brown clay to 23 inches. The substratum is a grayish-brown clay to 60 inches or more.

Permeability is very slow, natural fertility is low, O.M. is low, AWHC is medium, alkalinity is strong to very strong, and exchangeable sodium percentage (ESP) is 15 to 50.

Native vegetation on Notal soils consists of cheatgrass, alkali sacaton, big sagebrush, greasewood, annual forbs, and galleta.

Capacity for planting media differs greatly between these two soils. Blancot is good, although slope, seepage, and low strength are limiting factors; Notal is unsuitable because of sodium hazard, slow permeability, flood hazard, high clay content, shrink-swell potential, and low strength.

Inclusions is this mapping unit can range up to 20 percent. Dominant inclusions are Turley and Azfield, with minor inclusions of Forb, Persayo, Uffens, and Fruitland.

SMU 7014 - 09H - Huerfano-Muff-Uffens Complex, gently sloping, 704 acres - 5.79 percent of study area

This mapping unit is a complex of Uffens, Huerfano, and Muff soils. It is formed from moderately fine to fine alluvium and residuum from shale. It is found on mesa tops, shales, upland valley bottoms, and side slopes.

Huerfano soils, 35 to 45 percent of the association, have an estimated ESP of 25 to 75. The surface layer is typically about 1 inch of light yellowish-brown silty clay loam. The subsoil extends to a depth of 14 inches and is a light yellowish-brown and light olive-brown clay. Shale is encountered at 14 inches.

The AWHC and permeability are very low and very slow, respectively. These soils also have low natural fertility but are well drained.

Native vegetation is four-wing saltbush, alkali sacaton, and shadscale.

Muff soils, 25 to 35 percent of the association, also have an estimated ESP of 25 to 75. The surface layer is 3 inches thick and is a pale brown very fine sandy loam, followed immediately by a 1-inch layer of light gray very fine sandy loam. The subsoil, a brown clay loam, extends to a depth of 20 to 40 inches, where shale bedrock is again encountered.

Present vegetation is greasewood, alkali sacaton, four-wing saltbush, shadscale, and cheatgrass.

Uffens soils, 20 to 40 percent of the association, are moderately deep and well drained. The surface layer is 3 inches thick and is a pale brown very fine sandy loam, followed by a 1-inch layer of light gray very fine sandy loam. The subsoil is brown clay loam extending to a depth of 20 to 40 inches, where shales is encountered.

Other characteristics and vegetation are similar to the Muff series.

The entire association is unsuitable as planting media due to sodium hazard, low permeability, and AWHC.

SMU 7015 - R14 - Fruitland-Persayo-Sheppard Complex, hilly, 243 acres - 2.00 percent of study area

This complex consists of intermingled remnants of Fruitland, Pesayo, and Sheppard soils. It occupies nearly level to moderately steep upland hilly terrain adjacent to breaks, cliffs, bluffs, and escarpments.

Fruitland soils, 40 percent of the association, are deep well-drained soils derived from moderately coarse textured alluvium from shale and sandstone. They occupy valley side slopes and alluvial fans.

The topsoil of Fruitland is brown sandy loam to sandy clay loam. Subsoil is sandy loam to fine sandy loam with light yellowish-brown color. Stratified sands can occur between depths of 40 and 60 inches.

Permeability is moderately rapid and AWHC is medium. Depth to bedrock is usually greater than 60 inches. Similar to other soils in this region, Fruitland soils are low in both natural fertility and O.M.

Vegetation includes galleta, broom snakeweed, sand dropseed, and rubber rabbitbrush.

Persayo soils, 25 percent of the association, typically are shallow, consisting of light yellowish-brown clay loam overlying shale at a depth of 20 inches.

Permeability is moderate, AWHC is very low, and natural fertility and O.M. are low.

Vegetation is similar to Fruitland.

Sheppard soils, 25 percent of the association, have already been described under mapping unit 7004.

Soils of this complex are poor as planting media due to erosion hazard, AWHC, shallow soil depth, and shrink-swell potential.

Results of Weathering Tests Conducted on Core Samples from Kimbeto, New Mexico

Laboratory weathering and outdoor exposure tests were conducted on overburden core samples from the Kimbeto, New Mexico, study area. The purpose of these tests was to determine which materials would break down sufficiently to allow for their possible use as planting media in revegetation of strip-mined areas.

Tests procedures

Specimens for the laboratory weathering and outdoor exposure tests were cut from core samples submitted by regional personnel.

The purpose of including outdoor exposure tests was to determine if any correlation could be drawn between this type of weathering and the laboratory conditions.

A laboratory weathering cycle consisted of the following conditions:

1. 8 hours at 23.9° C (75° F), 100 percent relative humidity (wetting/thawing).

2. 16 hours (64 hours on weekends) at 37.8° C (100° F), 10 percent relative humidity (drying).

3. 8 hours at 23.9° C (75° F), 100 percent relative humidity (wetting).

4. 16 hours (64 hours on weekends) at -17° C (0° F) (freezing).

In this study, core specimens about 5 cm (2 in) in diameter by 5 cm (2 in) in length were used. For testing and handling, the core specimens were placed on a No. 10 mesh screen in 400-ml plastic beakers.

Laboratory weathering tests were started on December 13, 1977, and 20 laboratory weathering cycles were completed on February 10, 1978. Outdoor exposure tests commenced on December 6, 1977, and were completed on December 5, 1978. During this 1-year period, the specimens were subjected to 250 mm (10 in) of precipitation.

Tests results

Test results are summarized in table Q-5, and shown visually in figures Q-38 through Q-45.

At the completion of the weathering tests, a percent breakdown (%BD) value was determined for the specimens. This value listed under the remarks column in the table was derived as follows:

$$\%BD = \frac{(TW - IW)}{TW} (100)$$

where

TW = total specimen weight
IW = weight of original specimen remaining intact after testing

Of the ten samples tested, three sandstone (K-2, K-7, and K-10) and one sandy siltstone material (K-3) exhibited little or no breakdown at all.

The following materials appeared to have broken sufficiently to be considered for possible use as planting media:

sandstone sample K-4; shale sample K-6; siltstone sample K-8; and silty shale sample K-9.

With regard to correlation between laboratory and outdoor weathering conducted currently, the former appeared to be more severe. This was primarily due to the rather mild winter weather and low precipitation that the outdoor exposure specimens were subjected to.

Table Q-5

WEATHERING TESTS

Core Samples From Kimbeto, New Mexico

Sample I.D.	Remarks
Sandstone DH 1 Sample 1 Depth (ft) 73.9-74.7 (K-1)*	See Figures Q-39 and Q-43 Laboratory weathering: Very slightly friable at 20 cycles. %BD = 0 Outdoor: Scouring at 1 year. %BD = 32
Sandstone DH 3 Sample 1 Depth (ft) 158.2-159.0 (K-2)	See Figures Q-38 and Q-43 Laboratory weathering: Slightly friable at 20 cycles. Also slight surface peeling noted at 20 cycles. %BD = 0 Outdoor: Slight surface cracking at 1 year. %BD = 4
Sandy Siltstone DH 3 Sample 2 Depth (ft) 186.3-187.0 (K-3)	See Figures Q-39 and Q-43 Laboratory weathering: No change at 20 cycles. %BD - 0 Outdoor: Slight cracking at 1 year. %BD - 12
Sandstone DH 4 Sample 1 Depth (ft) 205.7-206.7 (K-4)	See Figures Q-39 and 43 Laboratory weathering: Slight slaking at 5 cycles. Continued slaking, 20 cycles. %BD = 24 Outdoor: Cracking and slaking at 1 year. %BD = 60

* Laboratory Sample Number

Table Q-5 (cont.)

WEATHERING TESTS

Core Samples From Kimbeto, New Mexico

Sample I.D.	Remarks
Shale DH 6 Sample 1 Depth (ft) 328.2-329.0 (K-5)	See Figures Q-40 and Q-44 Laboratory weathering: Slight slaking at 5 cycles; continued slaking at 20 cycles. %BD = 41 Outdoor: Cracking, scouring, and deformation at 1 year. %BD = 34
Shale DH 7 Sample 1 Depth (ft) 64.2-65.0 (K-6)	See Figures Q-40 and Q-44 Laboratory weathering: Slight slaking at 5 cycles; continued slaking at 20 cycles. %BD = 20 Outdoor: Severe slaking at 1 year. %BD = 100
Sandstone DH 8 Sample 1 Depth (ft) 102.0-102.8 (K-7)	See Figures Q-41 and Q-44 Laboratory weathering: Slightly friable at 20 cycles. %BD = 4 Outdoor: Slight scouring at 1 year. %BD = 24
Siltstone DH 8 Sample 2 Depth (ft) 170.6-174.4 (K-8)	See Figures Q-41 and Q-44 Laboratory weathering: Some slaking at 5 cycles; severe slaking at 20 cycles. %BD = 66 Outdoor: Slight surface cracking and slight slaking at 1 year. %BD = 22

Table Q-5 (cont.)

WEATHERING TESTS

Core Samples From Kimbeto, New Mexico

Sample I.D.	Remarks
Silty Shale DH 9 Sample 1 Depth (ft) 74.0-74.8 (K-9)	See Figures Q-42 and Q-45 Laboratory weathering: Slight slaking at 5 cycles; continued slaking at 20 cycles. %BD = 37 Outdoor: Severe slaking at 1 year. %BD = 100
Sandstone DH 9 Sample 2 Depth (ft) 262.0-262.9 (K-10)	See Figures Q-42 and Q-45 Laboratory weathering: No change at 20 cycles %BD = 0 Outdoor: No change at 1 year. %BD = 0

CH 1253 64NA

a. Original condition of test specimens.

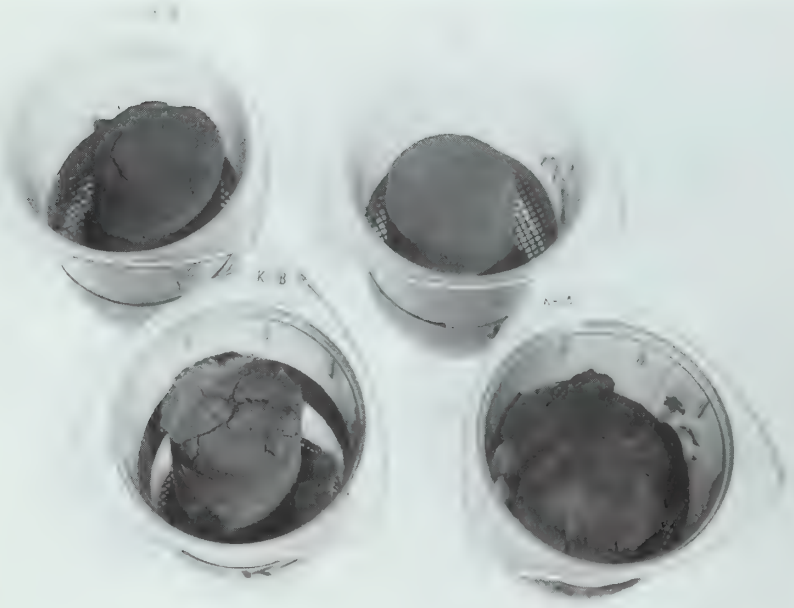
CH 1253 91NA

b. Condition of test specimens after weathering.

Figure Q-38. - Results of weathering tests for sandstone samples K-1 and K-2. Specimens A subjected to 20 laboratory weathering cycles; specimens B subjected to 15 weeks of outdoor exposure.

1253 65NA

a. Original condition of test specimens.



CH 1253 92NA

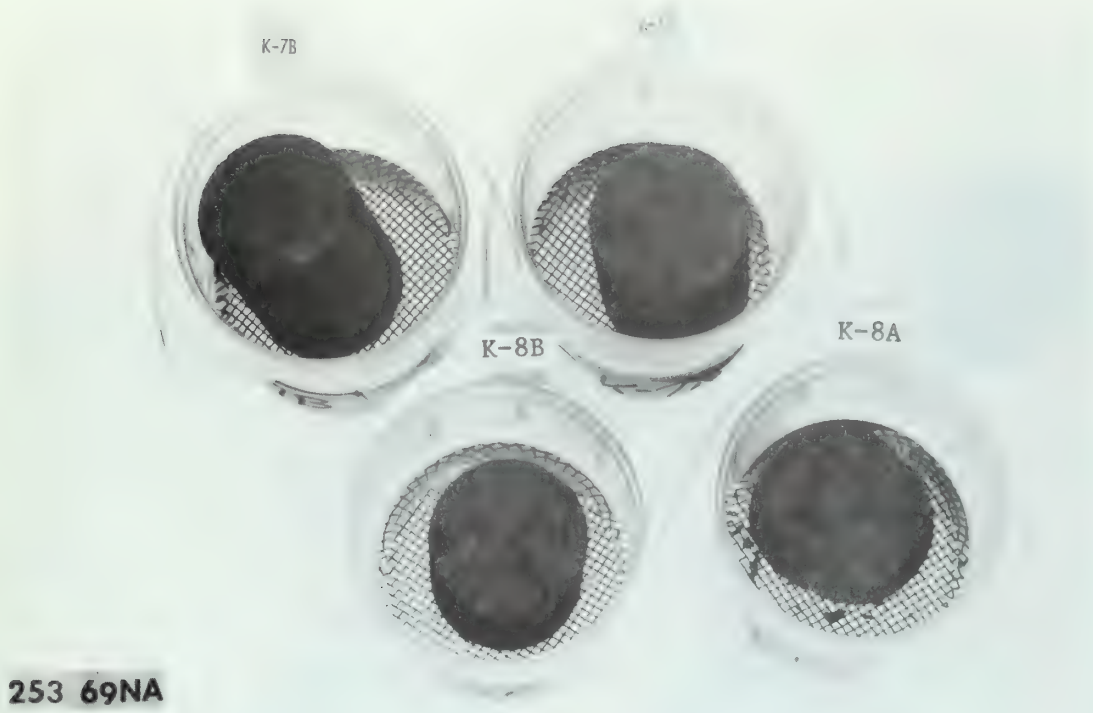
b. Condition of test specimens after weathering.

Figure Q-39. - Results of weathering tests for sandy siltstone sample K-3 and sandstone sample K-4. Specimens A subjected to 20 laboratory weathering cycles; specimens b subjected to 15 weeks of outdoor exposure.

a. Original condition of test specimens.

b. Condition of test specimens after weathering.

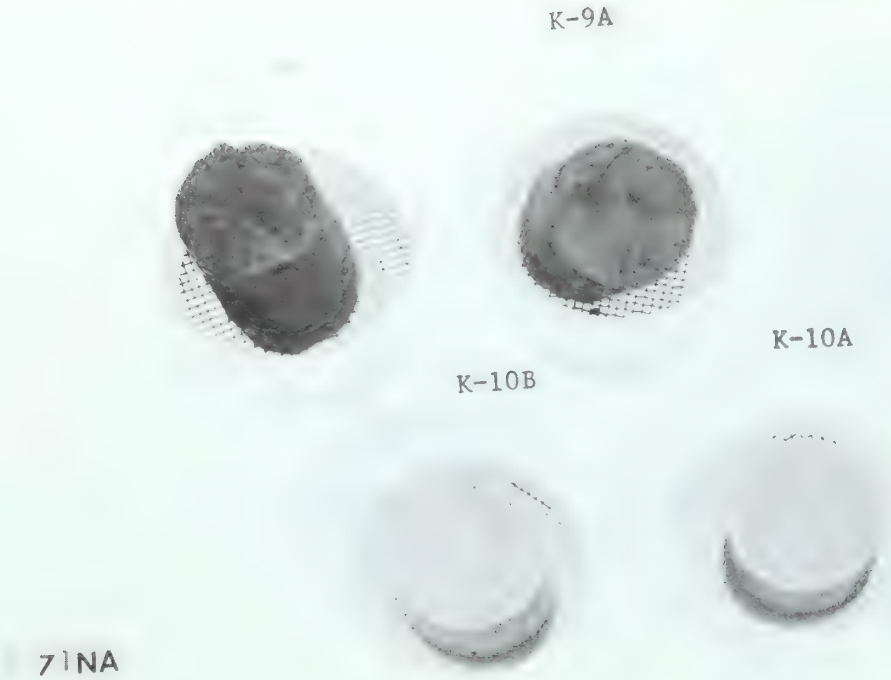
Figure Q-40. - Results of weathering tests for shale samples K-5 and K-6. Specimens A subjected to 20 laboratory weathering cycles; specimens B subjected to 15 weeks of outdoor exposure.



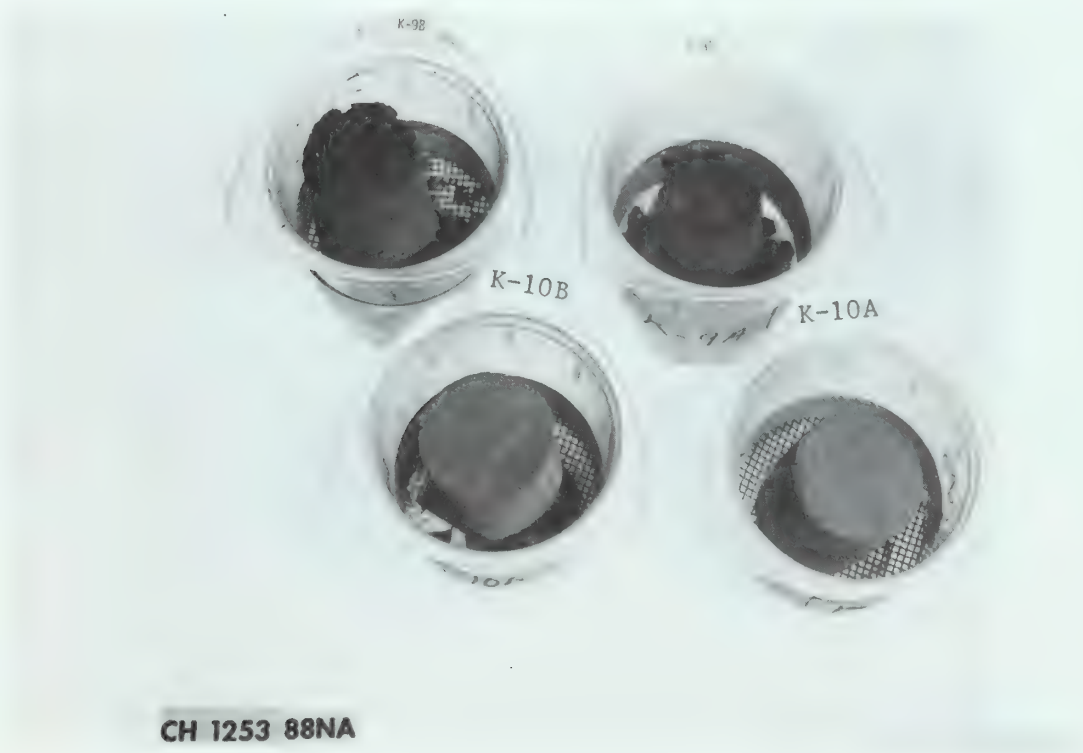
a. Original condition of test specimens.

b. Condition of test specimens after weathering.

Figure Q-41.- Results of weathering tests for sandstone sample K-7 and siltstone sample K-8. Specimens A subjected to 20 laboratory weathering cycles; specimens B subjected to 15 weeks of outdoor exposure.



a. Original condition of test specimens.



b. Condition of test specimens after weathering.

Figure Q-42. Results of weathering tests for silty shale sample K-9 and sandstone sample K-10. Specimens A subjected to 20 laboratory weathering cycles; specimens B subjected to 15 weeks of outdoor exposure.

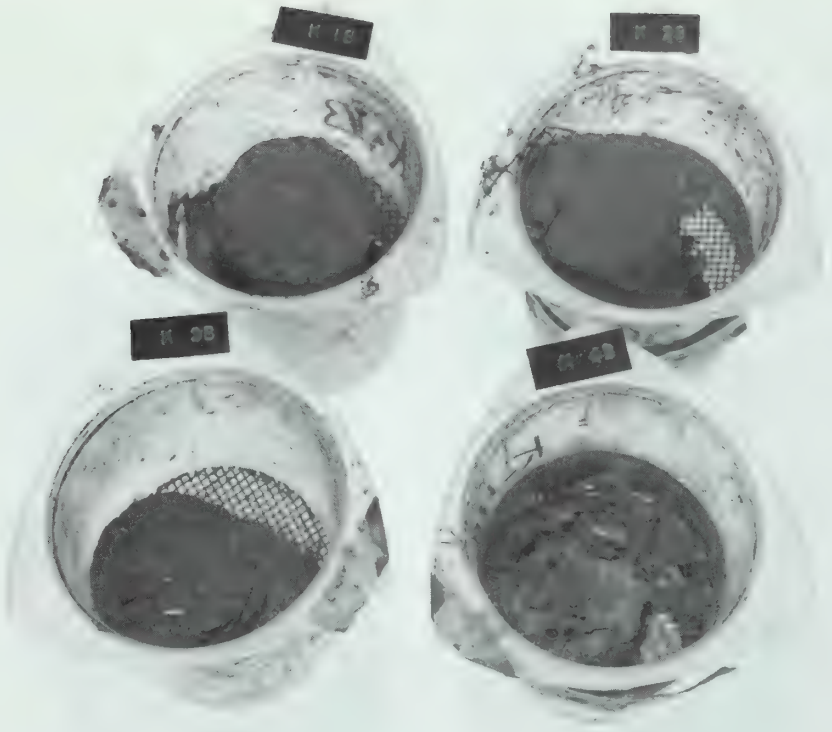


Figure Q-43. - Results of one-year outdoor weathering for Specimens K-1B, K-2B, K-3B and K-4B.

Figure Q-44. - Results of one-year outdoor weathering for Specimens K-5B, K-6B, K-7B and K-8B.

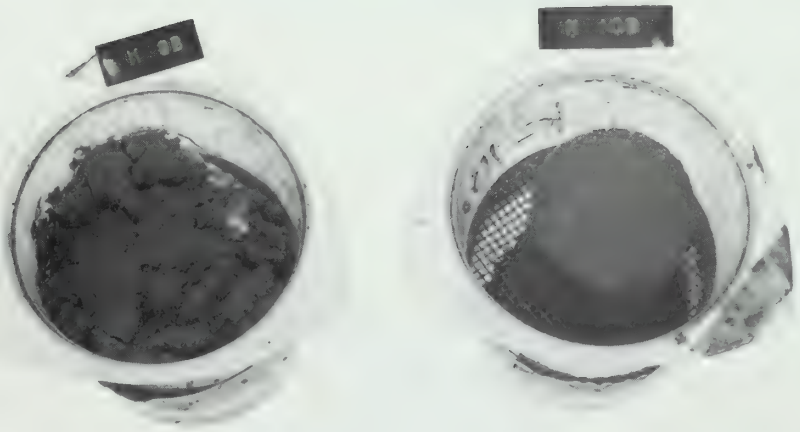


Figure Q-45. - Results of one-year outdoor weathering for Specimens K-9B and K-10B.

CHARACTERIZATION OF STRATA OVERLYING COAL SEAMS AS PLANT GROWTH MEDIA

FINAL REPORT*

CONTRACT NO. 6-07-DR-50130
U. S. BUREAU OF RECLAMATION

Prepared by

Dr. Robert D. Heil

Department of Agronomy

Colorado State University

Fort Collins, Colorado 80523

June, 1978

Soil Survey and Interpretations Research

* The complete report covers four study sites. However, only excerpts from the report which pertain to the Kimbeto study site are presented in this Kimbeto EMRIA report.

ACKNOWLEDGEMENTS

The help of Kathryn Beaumont, research technician, in carrying out the laboratory and greenhouse studies and data assembly is greatly appreciated.

INTRODUCTION

This report includes the results of greenhouse and laboratory studies to characterize soil and geologic overburden materials as plant growth media in relation to reclamation and revegetation of potential coal-mined areas. The study was carried out for the Bureau of Reclamation, U.S. Department of Interior, under Contract No. 6-07-DR-50130 and Amendatory Agreement No. 1 to the same contract.

The objectives of this study were to:

1. Characterize soil and overburden through greenhouse studies relating to revegetation of surface-mined areas; and

2. Conduct soil and plant analyses of selected materials for identifying potential problems relating to toxicity and/or nutrient deficiencies that may limit plant growth.

The information provided in this report reflects greenhouse and laboratory data obtained from the testing of soil and geologic material from the Kimbeto study site, New Mexico.

PROCEDURES

Greenhouse

Soil preparation

After the material was removed from the shipping bag, the material was mixed, and 100 grams was set aside for laboratory analysis. Two kilograms of the material was then placed in each of two plastic lined half-gallon round paper cartons and labeled in the following manner. Each carton carried the number used by the Bureau of Reclamation for cataloging purposes during recovery.

Field capacity

A part of the sample was placed in a tube and water was added to wet the soils two-thirds to three-quarters of the way down the tube. At the end of the wetting period (48 hours) the top 3 cm of soil was discarded while the middle section was placed in a soil moisture can, leaving about 2-5 cm of wet soil at the bottom of the tube. The soil moisture cans which had been previously weighed were then weighed with the wet soil and placed in a forced-air oven to dry at 100° C for at least 24 hours. They were then weighed again and percent field capacity was calculated by the formula:

(Weight of can + wet soil) - (weight of can + dry soil) ÷ (weight of can + dry soil) x 100 = % field capacity.

Field capacity was determined primarily to serve as a guide for insuring proper water management in the greenhouse.

Fertilizer treatment

Before planting, fertilizer application of 100 ppm of nitrogen as reagent grade $Ca(NO_3)2$ and 80 ppm of P as reagent grade $Ca(H_2PO_4)_2$, in five and fifty milliliter aliquots, respectively, was added to each pot. This was done along with the preplant watering. Before the fertilizer or water were added, 150 gms of soil was removed from each pot and saved to be placed back in the pot after the seeds were added. All except 100 ml of the total water was added 24 hours before planting.

An application of 80 ppm of K as KNO_3 was added to those materials on which corn was grown as a second crop*/ and to all materials from the Kimbeto site. Where sufficient soil material was not available for maintaining a 2 Kg. pot weight, the aliquots were adjusted to maintain the appropriate fertilizer level.

*/ Corn was not grown on Kimbeto materials.

Planting

The pots were planted with 40 seeds of western wheatgrass (Agropyron Smithii var. Arriba). The seeds were evenly spaced in the pots and covered with the 150 grams of soil that had been removed before fertilization took place. After smoothing the surface of the pot the last 100 mls of water was added and the pots were covered with brown paper to prevent evaporation. The pots were checked every day to assure that the topsoil remained moist. As the seeds started to germinate the pot was uncovered so as to prevent the development of spindly plants. After 2-1/2 weeks, or approximately 10 cm. height, the plants were counted and recorded for all pots, and then the pots were thinned to 16 plants and randomized. Pots were rotated one-third of the way around the table every third and fourth day to assure that all pots were subject to the same lighting. The greenhouse lights were set to allow 15-16 hours of daylight.

Daily mangement

All pots were weighed daily and brought to field capacity with distilled water. Nitrogen as reagent grade $(NH_3)_2SO_4$ was added at the rate of 50 ppm 21 days after planting. On the corn crop, 50 ppm of N was added every week thereafter, using reagent grade NH_4NO_3. At the time the pots were thinned, salt crusting and cracking were evaluated.

Harvest

The crop of western wheatgrass was harvested approximately 50 days after planting. This procedure entailed cutting the plants at approximately two centimeters above the surface of the material, washing in a .1 N HCl acid bath, rinsing twice in distilled water, placing in paper bags and drying at 60° C for 48 hours. Before cutting, the plants were measured and average height was recorded. After drying in a forced-air furnace, the plants were weighed to the nearest one-hundredth of a gram. Selected samples were then prepared for laboratory analysis.

Soil and Overburden Analysis

Electrical conductivity

Determined on a 1:1 dilution by using a solu-bridge. Insufficient sample did not allow for obtaining a saturated extract, thus soluble salts were determined on a 1:1 dilution. For interpretative purposes, the electrical conductivity obtained from the 1:1 dilution was multiplied by a factor of 2 to reflect the approximate EC of a saturation extract. The data, however, are reported for a 1:1 extract.

Iron, zinc, copper, and manganese

Determined on the Atomic Absorption Spectrophotometer from a DTPA extract.

pH

Determined with a combination electrode pH meter on a 1:1 dilution.

SAR

Determined according to procedure in Agricultural Handbook No. 60. The SAR reported is based on a 1:1 extract. For interpretation purposes, the SAR was converted using a calculation involving field capacity to approximate the SAR of the saturation extract.

Extractable Phosphorus

Extracted with sodium bicarbonate and determined colormetrically.

Plant Tissue Analyses

Na, K, Ca, Mg, Fe, Zn, Mn, and Cu were determined on the Atomic Absorption Spectrophotometer from a Perchloric Acid digest.

Phosphorus was extracted by the Bartons Reagent method and determined colormetrically.

Note: Laboratory data is lacking for some materials because of insufficient sample and/or because of the lack of funding for carrying out all analyses.

CRITERIA FOR INTERPRETATION

The criteria as applied in this study are based on existing data used for evaluating soil-plant growth relationships on agronomic crops.

The use of these criteria was necessary due to the lack of information available for the soil-plant-climatic environments associated with mined lands in the areas under investigation.

The criteria used for evaluating salinity and sodium problems are thought to be very reliable. However, the limits defined for the other soil and plant chemical characteristics must be considered as being somewhat arbitrary. They must be considered as a first approximation, using existing diagnostic data, in an attempt to identify and/or isolate potential problems associated with the growth of plants on these types of materials.

Soil Diagnostic Criteria */

The following criteria are based on current Colorado State University soil testing evaluation procedures.

Available P

0 to 3 ppm - very low
4 to 7 ppm - low
8 to 11 ppm - medium
11+ ppm - high

Available Zinc

0 to 0.5 ppm - very low
0.51 to .99 ppm - low
1.0 to 1.5 ppm - medium
1.5+ ppm - high

Available Iron

0 to 2.0 ppm - low
2.1 to 4.0 ppm - medium
4.0+ ppm - high

*/ This criteria differs somewhat from the Bureau of Reclamation (Bureau) criteria presented in table F-1; therefore, suitability ratings resulting from the two sets of criteria may be somewhat inconsistent. The Bureau has not attempted to resolve this difference for this EMRIA report. The reader is, therefore, advised to remember the above difference in criteria when using the suitability ratings arrived at by the Bureau and by Colorado State University.

Available Copper and Manganese

0 to 0.5 ppm - low
0.5+ ppm - high

SAR

0 to 10 - low sodium hazard
10 to 15 - medium sodium hazard - potential problem
15+ - high - very high probability that a sodium problem exists and will seriously effect reclamation protential

Note: The SAR values reported are based on a 1:1 extract. For interpretive purposes, the following conversions was made to approximate the SAR of a saturation extract. The procedure is not recommended for common use. Saturation extracts were not used because of insufficient sample.

$$\text{SAR of Saturation Extract} = \sqrt{\frac{100}{\%\ \text{Saturation at Field Capacity}}} \times \text{SAR of 1:1 Extract}$$

Salinity

<4 mmho's electrical conductivity - low
4 to 8 mmho's electrical conductivity - moderate salinity problem
>8 mmho's electrical conductivity - high salinity problem

Plant Diagnostic Criteria

The following criteria are based on a general interpretation of existing plant analysis data. These criteria are presented here mainly to evaluate the relationship between soil test values and plant uptake data rather than as an indicator of a critical deficiency problem. The latter is not possible because of the lack of adequate data. No attempt has been made to identify toxicity levels.

Total phosphorus		Total zinc	
<0.1%	critical	<10.0 ppm	critical
.1-.2%	marginal	10-20 ppm	marginal
>0.2%	adequate	>20 ppm	adequate

Total copper

<5 ppm - potentially deficient
5-10 ppm - adequate
>10 ppm - for some plants, copper levels in excess of this amount may indicate a potential toxicity problem.

Total manganese

<.2 ppm - potentially deficient
>.2 ppm - adequate

Total potassium

0 to 1.0% - potentially deficient
1.0 to 2.0% - intermediate
>2.0% - adequate

Total calcium

0 to 0.25% - potentially deficient
0.25% or greater - adequate

Total manganese

0 to 0.25% - potentially deficient
0.25% or greater - adequate

Note: In many cases, the selected criteria were made arbitrarily because the critical values for various stages of growth of western wheatgrass are not known. The selected ranges are used in this text as the reference level for comparing yield vs. plant vs. soil test data. The levels used must not be interpreted as being valid for making concrete interpretations. False conclusions will result if they are used as such.

Statistical Analysis */

Statistical analysis of the data are not available for inclusion in this report. The data are being statistically analyzed, using both a cluster and discriminate analysis procedure.

*/ This and related information should be available early in 1982 from Colorado State University, contact Dr. Robert D. Heil, 303-491-6913.

RESULTS AND DISCUSSION

Introduction

The greenhouse and laboratory data are presented in this section on a site-by-site basis. The format of the discussion is as follows: (1) a brief discussion of the nature and purpose of the study on a site-by-site basis; (2) presentation of data in tabular form; and (3) an interpretive summary of the data.

As of the date of this publication, statistical analysis of the data is not available. The data are being statistically analyzed, using a cluster and discriminate analysis procedure. This procedure is being used in order to determine which soil characteristics are best correlated with relative productivity potential. The results of the statistical analyses will become part of a student's Master's degree program. */

Kimbeto Study Area

Studies performed

1. The greenhouse study was conducted to determine the relative yield potential of western wheatgrass among the materials tested and to correlate yield response with soil laboratory characterization data.

2. Preplant and postharvest soil analyses for selected soil properties were carried out on some materials to determine what chemical changes, if any, may occur in the materials when exposed to a weathering and crop environment.

Summary of results

Greenhouse and laboratory characterization data for all materials tested from this site are shown in table Q-6.

A total of 22 materials are classed as unsuitable for use as plant gowth media because of salinity and sodium. These samples are identified in table Q-7.

A total of 37 samples are classes as unsuitable because of sodium. These materials are identified in table Q-8.

Suitability ratings for materials not shown in tables Q-7 and Q-8 are shown in table Q-9.

*/ This and related information should be available early in 1982 from Colorado State University, contact Dr. Robert D. Heil, 303-491-6913.

The results obtained from the study of soil and geological materials from this site indicate the following:

1. Approximately 60 percent of the materials tested are unsuitable for use as plant growth media due to excess sodium and salinity or sodium alone (tables Q-7 and Q-8).

2. An additional 15 percent of the materials are rated as unsuitable because of moderately high sodium and/or salinity (see table Q-9). Even though the SAR and salinity levels for these samples do not fall into the defined critical category, it is felt by this investigator that they are sufficiently high to preclude th materials as having potential as plant growth media. Moderately high sodium and/or salinity levels, and in some cases high salinity levels, plus low field capacities and low yields suggest that these materials would pose serious management problems.

3. From the results, it appears that the following samples are potentially suited for use as plant gowth media:

K-AH-36-S4, K-AH-80-S1, K-AH-15-S1, K-AH-62-S3, K-AH-10-S1, and K-AH-62-S2

The SAR values of the latter three materials indicate a serious sodium problem should exist. However, the yields obtained do not reflect this (see table Q-8). The only apparent explanation for this anomaly is that the field capacity of each of these materials was intermediate in range. This may reflect a more favorable soil moisture regime condition. A comparison of SAR values vs. field capacity vs. yield indicates that with materials having similar SAR values, the yield decreased with decreasing field capacity. It is suggested that even though the yields obtained on the latter three samples were relatively high, they should not be used as plant growth media because the potential for a sodium problem existing is very high.

4. Preplant vs. postharvest soil test data were quite different for many materials, particularly with respect to sodium and salinity. In many cases, the postharvest soil analyses related better to yield than did the preharvest. In many cases, the Zn and Cu levels increased in the postharvest soil analysis vs. the preplant data. In the case of zinc, the increase often changed the zinc availability rating from low to adquate, but this occurred less frequently in the case of copper.

5. Soil, zinc, and copper levels were low in many materials, including some of the higher yielding materials. However, there is little or no evidence to suggest that these elements were a limiting factor to yield.

6. Preplant available P levels were very low to low in all materials tested. The data reflect available P prior to the time that P was added.

7. Surface cracking was observed on nearly all materials in the greenhouse, particularly on those materials with high sodium levels. In general, the physical condition of most of the materials appeared to be poor. The experience obtained in working with the materials from this site suggests that more emphasis needs to be placed on evaluating the effect of physical condition on plant growth.

8. Low field capacities made it difficult to maintain a good water management program. It appears that this characteristic may have been one of the major reasons for the low yields obtained on many of the materials rated as "Questionable" in table Q-9. Serious drought conditions could occur which would make it difficult to stabilize these materials. The erosion potential may be very high on these materials.

9. Mg to Ca ratios of the 1:1 saturation extract were, in some cases, sufficiently high to warrant concern about potential magnesium induced calcium deficiencies. However, because the water soluble ratios were determined on a 1:1 dilution basis, it was difficult to assess this relationship. In addition, it appears that the effect of high Mg to Ca ratios also is related to salinity levels. Both the ratios of Mg to Ca and salinity levels changed as a function of pre vs. postplant soil or geologic overburden condition. The significance of these changes on yield are being evaluated through statistical analyses of the data. These results are not yet available. The frequency of occurrence of high Mg to Ca ratios indicates that this relationship needs further investigation and evaluation.

Table Q-6 GREENHOUSE AND LABORATORY DATA

Site Name: Kimbeto, New Mexico

Sample Set Represented: DH-1-1 through DH-3-12

GREENHOUSE DATA

Sample No.	Depth (ft.)	Pot Wt. (gms.)	Germination Time (days)	Yield gms./pot	Relative Yield %	Ave. Plant Height (cm.)	Field Cap. %
DH-1-1	--	2000	10	.97	46 b, c	23.5	38
4	--	2000	8	1.38	66 c	30.0	--
7	--	2000	7	1.44	69 b, c	28.5	--
8	--	2000	8	1.22	58 b, c	28.0	23.4
11	--	2000	11	.43	20 b	16.0	18.9
14	--	2000	11	.97	46 b, c	23.5	37.9
3-2	--	2000	10	1.22	58 b, c	26.5	33.0
6	--	2000	10	.78	37 c	24.5	42.9
10	--	2000	9	.94	45 b, c	25.0	--
12	--	2000	11	1.09	52 b, c	27.0	26.0
Control	--	2000	6	2.1	100	24.5	22.8

b=salt crusting present c=surface cracking present

SOIL LABORATORY DATA

(Pre-Plant)

Sample No.	Avail. Plant Nutrients (ppm) P	Zn	Fe	Cu	Mn	pH 1:1	Elect. Cond. 1:1	SAR	Water Soluble Cations meq/l 1:1 dil. Ca	Mg	Na	K
DH-1-1	no data											
4	no data											
7	no data											
8	no data											
11	no data											
14	no data											
3-2	no data											
6	no data											
10	no data											
12	no data											

(Post Plant)

DH-1-1	3.31	128.	4.72	4.1	5.4	7.2	33.0	6.2	3.0	70.1	.97
4	2.95	35.6	.59	.9	8.5	2.1	7.5	5.5	23.3	28.2	3.8
7	3.60	14.6	.52	.25	9.3	4.1	39.4	1.0	1.0	39.3	.02
8	4.15	10.9	.52	.54	9.2	---	---	---	---	---	---
11	2.84	29.1	.29	12.7	8.7	3.5	---	---	---	---	---
14	4.49	67.2	2.53	19.4	8.7	---	---	---	---	---	---
3-2	2.09	2.99	2.48	7.4	8.3	7.6	28.1	8.1	2.1	63.4	.69
6	8.79	88.6	3.78	5.3	8.5	5.0	14.5	5.7	14.9	45.8	7.7
10	2.45	16.1	.49	.86	8.8	2.9	25.6	1.3	.8	26.3	.33
12	4.15	50.9	2.01	14.2	8.9	4.0	8.6	7.0	35.2	39.3	18.0

Table Q-6 GREENHOUSE AND LABORATORY DATA (cont.)

Site Name: Kimbeto, New Mexico

Sample Set Represented: DH-4-4 through DH-6-19

GREENHOUSE DATA

Sample No.	Depth (ft.)	Pot Wt. (gms.)	Germination Time (days)	Yield gms./pot	Relative Yield %	Ave. Plant Height (cm.)	Field Cap. %
DH-4-4	--	2000	9	1.69	80	30.0	26
5	--	2000	10	.82	39 b, c	22.0	36.5
10	--	2000	8	1.11	53 b, c	24.0	38.5
14	--	2000	8	1.43	68 b	28.5	15.9
DH-6-3	--	2000	10	1.61	77 b, c	29.0	32.7
6	--	2000	11	.98	47 b, c	21.5	44.4
15a	--	2000	11	.92	44 c	20.5	49.0
16a	--	2000	12	.66	31 c	21.0	50.5
18	--	2000	8	.90	43 b	23.0	23.6
19a	--	2000	12	.48	23 c	18.0	49.0

a=data from one replication only b=salt crusting present c=surface cracking present

SOIL LABORATORY DATA

(Pre-Plant)

Sample	Avail. Plant Nutrients (ppm) P	Zn	Fe	Cu	Mn	pH 1:1	Elect. Cond. 1:1	SAR	Water Soluble Cations meq/l 1:1 dil. Ca	Mg	Na	K
DH-4-4												
5												
10												
14												
DH-6-3	2	4.8	41.0	2.57	6.0	8.2	4.0	30.0	2.4	1.1	39.6	.13
6												
15												
16												
18												
19												

(Post Plant)

DH-4-4	3.46	28.8	.97	4.5	8.6	2.0	15.1	1.2	2.0	18.8	.44
5	3.72	84.1	2.13	4.6	8.6	3.5	8.6	9.2	24.6	35.3	9.5
10	5.46	51.0	1.04	18.5	8.5	3.0	9.9	7.5	19.7	36.2	3.4
14	3.51	26.7	.42	.61	8.5	1.7	15.0	.6	1.1	13.6	1.01
DH-6-3	4.97	25.2	2.26	6.5	8.4	4.4	36.8	2.0	.8	43.0	.22
6	3.75	62.8	3.61	6.5	8.5	4.9	---	---	---	---	---
15	7.48	101.4	4.04	5.2	8.5	5.5	14.7	6.1	12.9	45.4	6.9
16	4.80	91.1	1.36	.86	8.7	4.9	51.2	1.1	.6	46.2	.36
18	5.25	26.6	.47	.61	8.3	3.3	18.8	1.8	3.3	29.7	1.34
19	5.50	66.9	2.24	3.5	8.9	4.7	48.5	1.1	.7	45.3	.19

Table Q-6 CREENHOUSE AND LABORATORY DATA (cont.)

Site Name: Kimbeto, New Mexico

Sample Set Represented: D-H-7-1 through D-H-7-11

GREENHOUSE DATA

Sample No.	Depth (ft.)	Pot Wt. (gms.)	Germination Time (days)	Yield gms./pot	Relative Yield %	Ave. Plant Height (cm.)	Field Cap. %
D-H-7-1	--	2000	10	1.24	59 b, c	26	47.1
3	--	2000	13	.93	44 c	24	31.9
4	--	2000	9	.98	47 b, c	23	40.7
5, a	--	2000	8	1.19	57 b, c	28	38.8
8	--	2000	11	.67	32 b, c	20	39.8
10	--	2000	11	.72	34 b, c	24	53.0
11	--	2000	10	.92	44 b, c	22.5	--

a=data from one replication only b=salt crusting present c=surface cracking present

SOIL LABORATORY DATA

(Pre-Plant)

Sample No.	Avail. Plant Nutrients (ppm) P	Zn	Fe	Cu	Mn	pH 1:1	Elect. Cond. 1:1	SAR	Water Soluble Cations meq/l 1:1 dil. Ca	Mg	Na	K
D-H-7-1	--	--	--	--	--	--	--	--	--	--	--	--
3	2	1.75	64.5	1.78	3.2	8.5	4.1	39.8	1.6	.8	43.8	.2
4	--	--	--	--	--	--	--	--	--	--	--	--
5	--	--	--	--	--	--	--	--	--	--	--	--
8	--	--	--	--	--	--	--	--	--	--	--	--
10	1	1.37	58.1	2.05	1.0	8.8	2.1	30.0	.7	.4	22.4	.05
11	--	--	--	--	--	--	--	--	--	--	--	--

(Post Plant)

D-H-7-1		.77	12.5	2.18	1.7	8.3	6.7	29.3	7.6	2.1	64.5	.36
3		4.26	62.7	2.01	4.3	8.5	6.0	16.5	--	--	50.8	--
4		4.51	74.8	1.95	4.7	8.6	5.1	42.2	1.8	.8	50.3	.36
5		3.79	25.9	.89	3.8	8.8	2.5	10.2	4.6	12.8	28.9	1.11
8		6.72	46.4	1.32	1.1	9.0	4.2	45.3	.6	0.5	40.8	--
10		7.64	52.7	2.11	1.5	8.8	5.4	53.2	1.5	0.8	51.9	.49
11		3.50	18.7	.52	.60	9.1	2.7	36.5	0.6	0.3	--	--

Table Q-6 GREENHOUSE AND LABORATORY DATA (cont.)

Site Name: Kimbeto, New Mexico

Sample Set Represented: DH-8-3, 5, 8, 9 and DH-9-1, 4, 8, 10

GREENHOUSE DATA

Sample No.	Depth (ft.)	Pot Wt. (gms.)	Germination Time (days)	Yield gms./pot	Relative Yield %	Ave. Plant Height (cm.)	Field Cap. %
DH-8-3	--	2000	11	.78	37 b, c	22	46.5
5	--	2000	10	1.24	59 b, c	30	34.2
8	--	2000	12	.48	23 b, c	22	1.8
9	--	2000	8	.99	47 b, c	25.5	--
9-1	--	2000	9	1.27	60 b, c	28.0	47.2
4	--	2000	9	1.28	61 b, c	29.0	--
8	--	2000	11	.64	30 b, c	24.0	21.5
10	--	2000	8	1.20	.57 b, c	28.0	24.7

b=salt crusting present c=surface cracking present

SOIL LABORATORY DATA

(Pre-Plant)

Sample No.	Avail. Plant Nutrients (ppm) P	Zn	Fe	Cu	Mn	pH 1:1	Elect. Cond. 1:1	SAR	Water Soluble Cations meq/l 1:1 dil. Ca	Mg	Na	K
DH-8-3	2	1.29	74.8	.77	9.2	8.6	1.6	19.0	.8	.5	15	.05
DH-8-5												
8												
9												
9-1												
4												
8												
10												

(Post Plant)

DH-8-3	3.80	57.9	1.15	10.8	8.5	2.6	30.2	1.0	0.4	25.0	.30
5	4.96	98.1	2.00	11.9	8.4	3.7	40.1	1.1	0.4	34.9	.40
8	7.91	54.4	2.93	.74	8.7	4.9	--	1.3	0.7	--	.41
9	3.49	26.6	.56	1.5	8.9	3.0	39.6	.8	0.4	29.9	.31
9-1	3.25	30.4	5.76	16.7	8.4	2.8	29.3	1.2	0.5	26.1	.27
4	3.93	9.6	.86	1.4	8.8	3.2	36.4	1.0	0.6	31.4	.24
8	4.84	79.2	..89	1.1	8.7	5.2	56.2	1.4	0.7	55.8	.46
10	2.17	26.5	.39	7.2	8.9	3.0	39.8	.07	0.3	27.9	.42

Table Q-6 GREENHOUSE AND LABORATORY DATA (cont.)

Site Name: Kimbeto, New Mexico

Sample Set Represented: K-AH-8-S2 through K-AH-13-S3

GREENHOUSE DATA

Sample No.	Depth (ft.)	Pot Wt. (gms.)	Germination Time (days)	Yield gms./pot	Relative Yield %	Ave. Plant Height (cm.)	Field Cap. %
K-AH-8-S2	0-4.0	2000	9	.55	26	24.0	18.6
S3	4.0-6.8	1950	9	1.34	64 b, c	29.0	46.0
9-S1	0-4.5	2000	7	.56	27	22.5	13.9
S2	4.5-9.0	1925	6	1.30	62	27.5	16.2
10-S1	0-3.0	2000	8	2.26	108	33.5	22.9
S3	7-9.7	1925	10	.63	30 b	24.0	30.4
13-S2	---	2000	8	.95	45	27.5	15.1
S3	---	2000	14	.52	25 b, c	20.0	47.6

b=salt crusting present c=surface cracking present

SOIL LABORATORY DATA

(Pre-Plant)

Sample No.	Avail. Plant Nutrients (ppm) P	Zn	Fe	Cu	Mn	pH 1:1	Elect. Cond. 1:1	SAR	Water Soluble Cations meq/l 1:1 dil. Ca	Mg	Na	K
K-AH-8-S2	--	--	--	--	--	--	--	--	--	--	--	--
S3	2	1.57	20.8	1.52	5.2	8.2	.8	4.0	2.4	1.0	5.2	0.05
9-S1	--	--	--	--	--	--	--	--	--	--	--	--
S2	2	.46	5.9	.26	3.3	8.4	.8	2.4	5.0	1.1	4.1	.28
10-S1	--	--	--	--	--	--	--	--	--	--	--	--
S3	2	.47	9.8	.63	6.1	9.0	.8	5.2	3.0	9.4	12.9	1.53
13-S2	2	.35	3.6	.24	3.4	8.8	1.7	5.8	4.6	2.2	10.8	.74
S3	6	1.80	43.8	3.35	3.0	7.6	11.8	42.2	14.8	4.2	13.0	.51

(Post Plant)

K-AH-8-S2	.53	8.3	.45	9.5	8.5	1.6	19.8	.8	.3	13.8	.09
S3	1.44	31.7	1.96	4.7	8.0	8.3	45.9	4.1	1.6	78.1	.43
9-S1	.44	4.2	.25	4.7	7.9	.8	.7	6.1	.4	1.2	.20
S2	.39	4.9	.23	4.1	8.1	1.3	7.1	2.7	.3	8.6	.30
10-S1	.62	5.5	.79	3.4	7.9	2.7	17.2	3.7	.4	24.4	.43
S3	.33	9.4	.67	4.2	8.4	2.0	19.6	1.1	1.1	18.6	.42
13-S2	.30	3.4	.24	4.5	8.2	2.1	16.8	2.2	.4	18.4	.46
S3	1.46	23.1	2.57	3.2	7.8	13.5	36.0	25.3	5.2	14.1	.87

Table Q-6 GREENHOUSE AND LABORATORY DATA (cont.)

Site Name: Kimbeto, New Mexico

Sample Set Represented: K-AH-15-S1 through K-AH-24-S1

GREENHOUSE DATA

Sample No.	Depth (ft.)	Pot Wt. (gms.)	Germination Time (days)	Yield gms./pot	Relative Yield %	Ave. Plant Height (cm.)	Field Cap. %
K-AH-15-S1	0-3.0	2000	6	1.85	88	31.5	16.5
S3	5.5-7.8	2000	9	.54	26 b	22.0	27.8
19-S1	0-3.0	2000	7	1.29	61	27.0	11.7
S3	6.0-9.5	1650	7	.99	47	25.5	25.6
23-S1	0-1.5	1750	10	.12	6 c	15.5	18.1
S3	3.8-7.5	1500	8	.37	18	19.0	18.2
24-S1	0-1.5	2000	8	1.76	84	32.0	15.2

b=salt crusting present c=surface cracking present

SOIL LABORATORY DATA

(Pre-Plant)

Sample No.	Avail. Plant Nutrients (ppm) P	Zn	Fe	Cu	Mn	Sat. pH 1:1	Cond. 1:1	SAR	Water Soluble Cation meq/l 1:1 dil. Ca	Mg	Na	K
K-AH-15-S1	3	.39	3.0	.31	3.9	8.3	.5	1.7	2.4	1.3	2.3	.51
S3	4	.66	12.4	.44	2.6	8.0	9.2	26.7	17.6	2.0	83.8	3.6
19-S1	--	--	--	--	--	--	--	--	--	--	--	--
S3	2	.43	4.4	.34	2.3	9.1	1.2	5.1	7.3	16.6	17.7	4.3
23-S1	3	.41	6.6	.94	2.6	8.2	4.1	13.4	11.7	.5	33.1	.26
S3	2	.45	6.3	.37	4.7	8.4	1.5	10.6	1.4	1.6	13.0	.31
24-S1	--	--	--	--	--	--	--	--	--	--	--	--

(Post Plant)

K-AH-15-S1	.49	4.2	.32	6.3	7.8	1.3	2.8	6.0	.6	4.8	.67
S3	1.70	11.9	.45	3.9	8.0	11.7	32.3	22.8	2.7	115	.89
19-S1	1.00	3.1	4.5	7.2	7.8	1.50	.40	11.6	1.2	.9	.81
S3	1.24	5.8	.44	3.8	8.4	2.2	27.8	1.1	.4	13.5	.25
23-S1	.82	6.0	1.08	3.3	7.8	6.3	11.6	27.7	1.0	43.2	.74
23-S3	.75	6.2	.45	4.7	7.7	2.8	15.0	4.4	.4	23.4	.63
24-S1	1.02	4.5	.54	5.9	8.1	.9	4.8	2.3	.2	5.1	.28

Table Q-6 GREENHOUSE AND LABORATORY DATA (cont.)

Site Name: Kimbeto, New Mexico

Sample Set Represented: K-AH-26-S2 through K-AH-29-S1

GREENHOUSE DATA

Sample No.	Depth (ft.)	Pot Wt. (gms.)	Germination Time (days)	Yield gms./pot	Relative Yield %	Ave. Plant Height (cm.)	Field Cap. %
K-AH-26-S2	2.0-4.0	2000	8	.51	24	26.0	13.5
S4	5.8-10.0	1875	6	.49	23	22.5	10.4
27-S2	1.8-5.0	2000	7	.64	30 b	19.5	12.6
S3	5.0-10.0	1825	6	.17	8	10.0	11.9
29-S1	0-1.0	1500	8	.17	8 c	14.0	16.7
S3	3.0-6.8	2000	9	.73	35	25.5	13.1
S4	6.9-10.0	1700	8	.12	6 b	14.0	11.8

b=salt crusting present c=surface cracking present

SOIL LABORATORY DATA

(Pre-Plant)

Sample No.	Avail. Plant Nutrients (ppm) P	Zn	Fe	Cu	Mn	pH 1:1	Elect. Cond. 1:1	SAR	Water Soluble Cations meq/l 1:1 dil. Ca	Mg	Na	K
K-AH-26-S2	--	--	--	--	--	--	--	--	--	--	--	--
S4	3	.33	4.8	.18	2.4	8.1	.2	.7	1.0	.3	.6	.15
27-S2	--	--	--	--	--	--	--	--	--	--	--	--
S3	2	.32	2.1	.28	2.0	8.2	.3	3.9	.4	.6	2.8	.13
29-S1	2	.33	4.4	.87	4.8	8.2	.2	.5	1.1	.6	.5	.2
S3	--	--	--	--	--	--	--	--	--	--	--	--
S4	1	.23	1.9	.17	1.5	8.3	.9	6.5	1.5	.3	.6	.2

(Post Plant)

K-AH-26-S2		.48	4.5	.73	15.6	7.5	1.4	.3	8.3	2.4	.7	1.62
S4		.42	6.1	.36	5.2	7.4	1.5	.4	10.1	2.2	1.0	.78
27-S2		.42	2.7	.43	3.5	7.7	1.7	1.3	8.7	3.4	3.2	.92
S3		.40	2.6	.38	3.2	7.7	1.7	3.5	6.8	2.0	6.8	.51
29-S1		.52	5.6	.96	11.0	7.3	3.6	.3	24.2	7.6	1.2	1.4
S3		1.04	2.5	.40	4.6	8.1	2.6	7.2	5.5	3.3	14.9	.36
S4		1.64	2.4	.28	2.6	7.9	1.9	3.0	8.2	2.8	7.0	.44

Table Q-6 GREENHOUSE AND LABORATORY DATA (cont.)

Site Name: Kimbeto, New Mexico

Sample Set Represented: K-AH-30-S1 through K-AH-36-S4

GREENHOUSE DATA

Sample No.	Depth (ft.)	Pot Wt. (gms.)	Germination Time (days)	Yield gms./pot	Relative Yield %	Ave. Plant Height (cm.)	Field Cap. %
K-AH-30-S1	0-2.0	1750	7	.09	4	10.5	12.7
S2	2.0-5.0	1950	8	.43	20	19.0	13.7
33-S2	.67-2.8	1775	9	.23	11 b,c	12.0	20.2
S4	4.0-8.0	1675	9	1.24	59 b,c	28.5	23.2
S5	8.0-10.0	1625	8	.86	41 b	23.0	16.8
36-S1	0-1.0	1775	6	.41	20	18.0	12.7
S4	7.0-10.0	1675	8	2.33	111	30.0	28.0

b-salt crusting present c=surface cracking present

SOIL LABORATORY DATA

(Pre-Plant)

Sample No.	Avail. Plant Nutrients (ppm) P	Zn	Fe	Cu	Mn	pH 1:1	Elect. Cond. 1:1	SAR	Water Soluble Cations meq/l 1:1 dil. Ca	Mg	Na	K
K-AH-30-S1	3	.42	2.2	.35	4.3	8.3	.2	.7	1.2	.3	.6	.2
S2	2	.32	2.7	.41	3.2	9.0	.7	4.1	1.2	1.2	4.5	.33
33-S2	3	.31	3.7	1.07	3.4	8.2	2.7	12.9	4.8	.4	20.9	.18
S4	3	.48	4.9	1.21	1.6	8.3	1.6	11.5	2.2	.3	12.8	.08
S5	3	.48	4.1	.91	1.4	8.3	1.3	9.8	2.2	.3	10.9	.08
36-S1	4	1.25	2.4	0.17	3.4	8.0	0.2	0.2	1.4	0.2	0.2	.28
S4	2	.38	4.1	.27	2.4	9.3	1.8	3.6	2.9	9.2	8.8	.44

(Post Plant)

K-AH-30-S1		1.25	3.1	.42	8.6	7.4	1.5	.3	11.5	1.3	.9	.79
S2		1.13	3.2	.46	3.4	7.7	1.6	7.6	3.4	.4	10.6	.55
33-S2		.53	4.7	1.15	4.4	7.7	4.8	11.7	14.7	1.0	32.5	.61
S4		.56	6.7	1.28	2.5	7.7	3.9	11.9	11.9	.9	30.1	.63
S5		.76	.62	1.15	3.1	7.5	3.0	8.1	10.9	.9	19.7	.71
36-S1		1.22	2.8	.35	4.6	8.7	1.8	1.9	4.0	10.2	5.2	.51
S4		.54	5.2	.35	2.4	8.6	1.9	2.1	5.0	10.8	5.9	.64

Table Q-6 GREENHOUSE AND LABORATORY DATA (cont.)

Site Name: Kimbeto, New Mexico

Sample Set Represented: K-AH-37-S1 through K-AH-46-S4

GREENHOUSE DATA

Sample No.	Depth (ft.)	Pot Wt. (gms.)	Germination Time (days)	Yield gms./pot	Relative Yield %	Ave. Plant Height (cm.)	[illegible]
K-AH-37-S1	0-1.0	2000	8	.94	45	27.0	9.5
S2	1.0-2.7	1700	8	.42	20	16.0	15.5
S6	6.2-6.7	1500	9	.56	27 b, c	22.0	54.0
39-S1	0-1.0	1800	9	1.58	75	30.0	31.1
S4	6.5-10.0	2000	8	1.01	48	24.5	14.1
46-S1	0-0.7	1800	8	.12	6	14.5	12.1
S4	5.0-10.0	2000	7	.86	41	24.0	12.4

b=salt crusting present c=surface cracking present

OIL LABORATORY DATA

(Pre-plant)

Sample	Avail. Plant Nutrients (ppm) P	Zn	Fe	Cu	Mn	pH 1:1	Cond. 1:1	SAR	Water Soluble cations meq/l Ca	Mg	Na	K
K-AH-37-S1	--	--	--	--	--	--	--	--	--	--	--	--
S2	2	.38	3.9	.72	5.2	8.2	.5	2.2	1.2	1.5	2.5	.48
S6	2	2.62	12.3	2.90	.84	8.2	2.3	21.0	1.4	0.7	21.0	.10
39-S1	3	.41	5.8	.70	3.9	8.5	1.7	5.5	9.1	9.4	16.9	1.91
S4	--	--	--	--	--	--	--	--	--	--	--	--
46-S1	3	.60	3.3	.42	6.3	8.2	0.2	0.1	1.1	0.7	0.1	0.31
S4	--	--	--	--	--	--	--	--	--	--	--	--

(Post Plant)

K-AH-37-S1	.45	4.1	.45	6.0	7.5	1.2	.3	7.7	1.6	.7	.63
S2	.51	4.5	.78	8.3	7.6	1.4	3.4	5.1	1.8	6.3	.36
S6	2.44	14.3	3.14	1.4	7.6	4.2	22.8	4.2	2.1	40.0	.17
39-S1	.62	7.4	.74	4.5	8.1	3.3	17.3	5.4	.3	29.4	.49
S4	.51	3.8	.37	2.7	8.3	1.2	10.1	1.6	.3	9.7	.27
46-S1	.55	5.1	.53	9.2	7.4	2.1	0.2	15.4	2.7	0.4	1.3
S4	.92	3.1	.15	2.3	7.8	1.4	1.7	6.3	2.2	3.5	.88

Table Q-6 GREENHOUSE AND LABORATORY DATA (cont.)

Site Name: Kimbeto, New Mexico

Sample Set Represented: K-AH-48-S1 through K-AH-59-S2

GREENHOUSE DATA

Sample No.	Depth (ft.)	Pot Wt. (gms.)	Germination Time (days)	Yield gms./pot	Relative Yield %	Ave. Plant Height (cm.)	Field Cap. %
K-AH-48-S1a	--	2000	8	1.22	58	27	16.0
54-S1	0-1.2	1400	8	1.30	62 c	30	21.9
S3	3.5-5.5	1600	9	1.18	56	30	19.7
58-S1	0-0.5	1575	8	1.54	73	31	27.0
S2	0.5-4.0	2000	8	.87	41	28	13.1
59-S2	2.0-4.0	2000	7	1.30	62	28.5	15.6

a=data from one replication only

c=surface cracking present

SOIL LABORATORY DATA

(Pre-Plant)

Sample No.	Avail. Plant Nutrients (ppm) P	Zn	Fe	Cu	Mn	pH 1:1	Elect. Cond. 1:1	SAR	Water Soluble Cations meq/l 1:1 dil. Ca	Mg	Na	K
K-AH-48-S1a		.27	3.8	27	3.8	8.9	.7	2.5	3.0	1.0	3.6	.28
54-S1		--	--	--	--	--	--	--	--	--	--	--
54-S3		--	--	--	--	--	--	--	--	--	--	--
58-S1		--	--	--	--	--	--	--	--	--	--	--
58-S2		--	--	--	--	--	--	--	--	--	--	--
59-S2		--	--	--	--	--	--	--	--	--	--	--

(Post Plant)

K-AH-48-S1a		.62	4.2	.29	4.5	8.2	1.2	7.0	2.7	.3	8.3	.35
54-S1		.83	10.2	1.05	5.6	8.1	2.4	15.1	3.3	.3	15.1	.47
S3		.65	10.3	.43	3.0	7.9	3.1	22.1	2.8	.2	26.1	.63
58-S1		.45	18.3	.69	5.9	8.3	2.1	18.6	1.6	.2	17.8	.42
58-S2		.39	4.2	.38	2.4	8.2	2.3	11.1	46	.2	16.9	.29
59-S2		.40	4.5	.25	5.6	8.1	1.2	4.6	4.0	.5	6.9	.34

Table Q-6 GREENHOUSE AND LABORATORY DATA (cont.)

Site Name: Kimbeto, New Mexico

Sample Set Represented: K-AH-62-S1 through K-AH-71-S1

GREENHOUSE DATA

Sample No.	Depth (ft.)	Pot Wt. (gms.)	Germination Time (days)	Yield gms./pot	Relative Yield %	Ave. Plant Height (cm.)	Field Cap. %
K-AH-62-S1	0-2.0	1825	8	1.30	62 b	28	17.7
S2	2.0-5.0	2000	8	2.23	106 b	36	29.4
S3	5.0-8.5	2000	7	2.28	109 b	34	24.0
S4	8.5-10.0	1800	9	1.00	48 b, c	26	66.5
69-S1	0-2.0	1775	7	1.61	77 b	30	17.3
S2	2.0-5.0	2000	7	.67	32	23.5	17.8
S3	5.0-10.0	1800	6	1.20	57	28.0	14.7
71-S1	0-2.4	1325	7	.24	11	16.5	17

b=salt crusting present c=surface cracking present

SOIL LABORATORY DATA

(Pre-Plant)

Sample No.	Avail. Plant Nutrients (ppm) P	Zn	Fe	Cu	Mn	pH 1:1	Elect. Cond. 1:1	SAR	Water Soluble Cations meq/l 1:1 dil. Ca	Mg	Na	K
K-AH-62-S1	3	.55	5.1	.56	2.9	8.6	.5	3.4	1.2	.8	3.4	.23
S2	4	.75	9.6	1.4	5.0	8.4	1.2	4.4	3.3	.8	8.2	.41
S3	--	--	--	--	--	--	--	--	--	--	--	--
S4	3	2.41	20.9	.39	1.5	8.2	8.5	42.1	5.2	2.5	82.5	.26
69-S1	2	.24	5.4	.54	4.9	8.4	.2	.9	1.2	.6	.9	.10
S2	--	--	--	--	--	--	--	--	--	--	--	--
S3	2	.22	2.4	.11	1.2	8.4	.8	5.3	.9	1.6	5.9	.08
71-S1	3	.24	3.3	.14	3.3	8.6	.4	2.0	1.4	1.0	2.2	.36

(Post Plant)

K-AH-62-S1	.57	4.9	.59	4.4	8.1	1.3	4.7	5.0	.4	7.1	.37
S2	.98	9.5	1.49	5.1	7.9	3.0	12.6	6.0	.8	23.3	.46
S3	.75	12.2	.94	4.6	7.9	1.6	11.3	2.4	.2	17.9	.38
S4	1.79	14.3	.66	1.9	7.8	10.8	28.3	21.1	3.9	99.4	1.04
69-S1	.41	4.2	.63	4.9	7.8	1.7	1.0	9.5	3.8	2.5	.48
S2	.39	4.3	.47	2.8	8.0	1.6	3.9	3.9	4.0	7.7	.13
S3	.25	2.5	.11	1.5	7.9	1.5	3.5	4.1	3.8	6.8	.37
71-S1	.39	.34	.18	4.9	7.7	2.3	1.8	10.2	.7	4.8	1.09

Table Q-6 GREENHOUSE AND LABORATORY DATA (cont.)

Site Name: Kimbeto, New Mexico

Sample Set Represented: K-AH-74-S1 through K-AH-84-S3

GREENHOUSE DATA

Sample No.	Depth (ft.)	Pot Wt. (gms.)	Germination Time (days)	Yield gms./pot	Relative Yield %	Ave. Plant Height (cm.)	Field Cap. %
K-AH-74-S1	0-4.0	1725	13	.48	23 b, c	21.0	34.3
80-S1	0-1.5	1900	7	1.99	95 b	30.0	16.5
S4	5.0-8.0	2000	8	.27	13	15.0	10.5
84-S1	0-0.7	1800	7	1.21	58	23.0	16.5
S3	3.3-5.5	1800	7	1.34	64 b	30.0	14.4

b=salt crusting present c=surface cracking present

SOIL LABORATORY DATA

(Pre-Plant)

Sample No.	Avail. Plant Nutrients (ppm) P	Zn	Fe	Cu	Mn	pH 1:1	Elect. Cond. 1:1	SAR	Water Soluble Cations meq/l 1:1 dil. Ca	Mg	Na	K
K-AH-74-S1	2	3.9	39.2	4.1	7.9	6.4	10.4	38.2	11.6	3.6	105	.41
80-S1	2	.13	4.6	.54	8.6	7.9	..2	.3	1.0	.6	.3	.20
S4	--	--	--	--	--	--	--	--	--	--	--	--
84-S1	2	.25	4.3	.39	6.3	7.9	.2	.2	1.1	.7	.2	.26
S3	2	.12	3.5	.26	3.2	8.6	.5	4.2	1.2	.6	3.9	.08

(Post Plant)

K-AH-74-S1		4.48	57.1	4.26	7.5	6.1	10.2	36.6	8.8	4.0	112.6	.83
80-S1		.29	5.2	.50	12.2	7.7	1.2	.3	7.8	2.4	.7	.66
S4		.26	1.7	.11	2.5	7.9	2.7	2.5	16.3	6.1	8.3	.57
84-S1		.25	5.3	.34	8.5	7.6	1.7	.2	11.5	3.1	.6	.82
S3		.27	3.6	.25	5.7	8.1	.14	4.6	3.1	2.3	7.4	.17

Table Q-6 GREENHOUSE AND LABORATORY DATA (cont.)

Site Name: Kimbeto, New Mexico

Sample Set Represented: K-AH-86-S1 through K-AH-88-S1

GREENHOUSE DATA

Sample No.	Depth (ft.)	Pot Wt. (gms.)	Germination Time (days)	Yield gms./pot	Relative Yield %	Ave. Plant Height (cm.)	Field Cap. %
K-AH-86-S1a	0-0.7	2000	8	1.15	55	30	29.7
87-S1	0-2.0	2000	6	1.52	72 b	27.0	14.6
S2	2.0-5.0	1875	6	1.22	58 b	25.0	15.7
88-S1	0-1.7	1800	8	1.58	75	31.0	20.7

a=data from 1 replication only b=salt crusting present

SOIL LABORATORY DATA

(Pre-Plant)

Sample No.	Avail. Plant Nutrients (ppm) P	Zn	Fe	Cu	Mn	pH 1:1	Elect. Cond. 1:1	CAR	Water Soluble Cations meq/l 1:1 dil. Ca	Mg	Na	K
K-AH-86-S1		.21	5.3	.54	6.5	8.6	0.9	8.5	1.4	0.6	85	.15
87-S1		--	--	--	--	--		--	--	--	--	--
S2		.11	2.8	2.2	3.6	8.3	.3	1.4	1.5	.5	1.5	.13
88-S1		.38	2.5	.20	3.8	8.5	.8	5.7	2.0	.5	6.4	.15

(Post Plant)

K-AH-86-S1		.35	4.8	.75	7.6	8.2	2.7	23.0	1.6	.4	23.3	.15
87-S1		.38	2.2	.32	6.7	7.8	1.2	.2	9.6	1.0	.4	.69
87-S2		.98	2.6	.35	5.8	7.9	1.4	.7	9.3	2.0	1.5	.30
88-S1		.37	2.7	.31	5.2	8.1	1.6	12.2	2.1	.5	13.8	.21

Table Q-7 Kimbeto Site Materials Classed as Unsuitable due to Salinity and SAR

Sample No.	% Relative Yield
DH-1-7	69
K-AH-8-S3	64
DH-7-1	59
DH-3-2	58
K-AH-62-S4	48
DH-7-4	47
DH-6-15	44
DH-7-3	44
DH-3-6	37
DH-7-10	34
DH-6-16	31
DH-9-8	31
K-AH-37-S6	26
K-AH-15-S3	26
DH-1-1	46
K-AH-13-S3	25
DH-6-19	23
K-AH-74-S1	23
K-AH-33-S2	11
K-AH-23-S1	6
DH-6-3	77
DH-7-8	32

Table Q-8 Kimbeto Site Materials Classed as being Unsuitable due to SAR

Sample No.	% Relative Yield
K-AH-62-S3	109
K-AH-10-S1	108
K-AH-62-S2	106
K-AH-88-S1	75
DH-4-4	80
DH-4-14	68
K-AH-39-S1	75
K-AH-58-S1	73
K-AH-9-S2	62
K-AH-54-S1	62
DH-9-1	60
DH-9-10	57
DH-8-5	59
K-AH-33-S4	59
K-AH-48-S1	58
DH-7-5	56
K-AH-54-S3	56
K-AH-86-S1	55
DH-4-10	53
DH-3-12	52
DH-3-10	45
K-AH-37-S1	45
K-AH-13-S2	45
DH-7-11	44
DH-6-18	43
K-AH-58-S2	41
K-AH-33-S5	41
DH-8-3	37
K-AH-29-S3	35
K-AH-10-S3	30
K-AH-8-S2	26
K-AH-30-S2	21
K-AH-23-S3	18
DH-8-9	47
DH-1-4	66
DH-9-4	61
K-AH-30-S4	48

Table Q-9 Suitability ratings for Kimbeto site Materials not shown in Tables Q-7 and Q-8

Sample No.	% Relative Yield	Remarks	Suitability Rating
K-AH-36-S4	111	Salinity level moderately high; field capacity indicates good water holding capability	Suitable (if salts do not accumulate)
K-AH-80-S1	95	No apparent problem; pre and post-plant Zn level low.	Suitable
K-AH-15-S1	88	No apparent problem; pre and post-plant Zn level low.	Suitable
K-AH-24-S1	85	Post-plant SAR moderately high.	Questionable
K-AH-69-S1	77	Salt crusting and surface cracking evident in greenhouse pots. Pre and post-plant Zn level low.	Questionable
K-AH-87-S1	72	Salt crusting observed. Post-plant soil Cu and Zn levels potentially deficient; post plant Fe marginal.	Questionable
K-AH-84-S3	64	SAR marginally high; pre and post-plant soil Cu and Zn low.	Questionable to unsuitable
K-AH-62-S1	62	Post-plant SAR moderately high; salt crusting occurred.	Unsuitable
K-AH-59-S2	62	(Same as above)	Unsuitable
K-AH-19-S1	61	Low field capacity .	Questionable to suitable
K-AH-84-S1	58	Salt crusting occurred; pre and post-plant soil Zn level low. Low field capacity.	Questionable
K-AH-87-S2	58	Salt crusting occurred; pre and post-plant soil Cu level low. Low field capacity.	Questionable
DH-1-8	58	pH indicates high sodium; salt crusting and surface cracking occurred.	Questionable to unsuitable
K-AH-69-S3	57	Post-plant SAR moderately high; pre and post-plant soil Zn and Cu level low.	Unsuitable
DH-6-6	47	High salinity; pH suggests high sodium.	Unsuitable
DH-1-14	46	Post-plant soil pH suggests high sodium; salt crusting and surface cracking occurred.	Unsuitable
K-AH-46-S4	41	Post-plant soil Cu level low; low field capacity.	Unsuitable
DH-4-5	39	Post-plant soil salinity and SAR moderately high.	Unsuitable
K-AH-69-S2	32	Post-plant SAR moderately high. Post-plant Zn and Cu level low.	Unsuitable
K-AH-27-S2	31	Low field capacity; salt crusting. Post-plant Zn and Cu level low.	Unsuitable
K-AH-9-S1	27	Low field capacity; salt crusting. Post plant Zn and Cu level low.	Unsuitable
K-AH-26-S2	24	Low field capacity; salt crusting. Low soil Zn level; low field capacity.	Unsuitable
DH-8-8	23	Soil salinity high; pH suggests high sodium.	Unsuitable
K-AH-26-S4	23	Post-plant Zn and Cu low; low field capacity.	Unsuitable
K-AH-36-S1	20	Post-plant Cu low; low field capacity.	Unsuitable
K-AH-37-S2	20	Low field capacity. SAR marginal.	Unsuitable
DH-1-11	20	Post-plant salinity high.	Unsuitable
K-AH-80-S4	13	Post-plant salinity moderate. Post-plant Zn and Cu low. Field capacity very low. SAR marginal.	Unsuitable
K-AH-71-S1	11	Post-plant salinity moderate. Post-plant Zn and Cu low.	Unsuitable
K-AH-29-S1	8	Post-plant salinity moderate. Pre and post Zn level low.	Unsuitable
K-AH-27-S3	8	Post-plant SAR moderately high; low field capacity; pre and post-plant Zn and Cu low.	Unsuitable
K-AH-46-S1	6	Post-plant salinity moderate; low field capacity.	Unsuitable
K-AH-29-S4	6	Preplant SAR high; low field capacity; significant changes occurred in the chemical characteristics of this soil during the pre and post-plant periods.	Unsuitable
K-AH-30-S1	4	Field capacity low. Pre and post-plant Cu low.	Unsuitable

GENERAL CONCLUSIONS

In general, the overall results of this study can be summarized as follows:

1. The effects of sodium and/or salinity on yield correlated well with soil test data.

2. Available phosphorus was low to very low in nearly all materials tested. The application of 80 ppm P appeared to raise the available P level in the material to a sufficient level. It is important to note that the added P was incorporated into the soil.

3. Soil zinc and copper levels were low (based on response by agronomic crops) in a large percentage of the materials. These low levels in the soil were, in most cases, reflected in the level found in the plants. There is some evidence that low soil zinc levels affected corn yields.*/ This same evidence does not exist with respect to western wheatgrass. On the other hand, the persistence of lower zinc levels in the plants raises the question of the nutrient quality of forage grown.

4. Low field capacity may have created a water management problem in the greenhouse which in turn affected yield. This characteristic raises the question of a high erosion potential associated with these materials.

5. In some cases, the greenhouse and laboratory characterization data obtained were not adequate for explaining some of the yield and other responses obtained in plant growth. This indicates that factors other than those observed are limiting productivity potential. This reflects the importance of greenhouse studies in stratifying materials relative to the need for further investigations. Without greenhouse data, the interpretive process will be more costly and less reliable.

6. The results obtained strongly suggest that studies are needed to evaluate the effects of weathering and crop environment on the chemical and physical properties of geologic materials. This is evident from the fact that in many cases postharvest soil test data related better to yield response than did preplant soil data.

7. It appears that the factors which determine yield or productivity potential on geologic materials are very complex, particularly when one considers the unavailability of soil-plant relationship data as it applies to mined land reclamation situations.

8. The results also indicate that more emphasis is needed in evaluating the effect of physical properties on yield potential.

---

*/ Corn was not grown on Kimbeto materials.

In summary, the results of this study appear to raise as many questions as can be answered. The data do, however, point out the need for and potential of establishing a screenable testing program which can minimize the amount of resources needed for determining the suitability of materials as plant growth media and at the same time allow for credible and reliable interpretations to be made.

Screenable Testing Laboratory Results

Description of and references for laboratory procedures

Soil samples from natural horizons and layers were tested in the laboratory. Tests in the following list were performed on soil samples as needed for proper evalution:

PSA - The procedure is a modification of the pipette method. The soil is not treated with hydrogen peroxide for destruction of organic matter and is not washed for removal of salts (Kilmer and Alexander, 1979).

Moisture retention - Porous plates are used for moisture retention measurement of soils at all pressures (Richards, 1947 and 1949b and Richards and Weaver, 1944).

Disturbed hydraulic conductivity - Soils are tamped mechanically. City water is used for the test. The temperature of the water is maintained at about 85 degrees F. (Fireman, 1944).

Settling volume - The soil used for the 1:5 dilution measurements is used for this determination. Distilled water and 1C ml of 30 percent calcium chloride solution are used (USBR, Reclamation Instructions, 1967).

pH - Measured with Beckman Expandomatic pH meter.

Saturation extract - Samples are mixed by hand and extract removed with a Baroid filter press. No preservative added.

Calcium and magnesium - Determined by EDTA titration.

Sodium and potassium - Determined with Baird-Atomic Model KY3 flame photometer and Perkin-Elmer Model 306 atomic absorption spectrophotometer.

Carbonate, bicarbonate, chloride, and sulfate - All are based on U.S. Geological Survey procedures (Brown and others, 1970).

The carbonate end-point is taken as pH 8.2.

Chloride is determined by the Mohr method.

Sulfate is determined by the Thorin method using Bausch & Lomb spectrophotometer Spectronic 20.

Nitrate - Determined by phenoldisulfonic acid method and Bausch and Lomb spectrophotometer Spectronic 20 (U.S. Salinity Laboratory Staff, 1954).

Exchangeable sodium and potassium - Based on soluble cations in saturation extract and extractable cations extracted with neutral normal ammonium acetate and measured with Baird Atomic Model KY3 flame photometer and Perkin-Elmer Model 306 atomic absorption spectrophotometer (U.S. Salinity Laboratory Staff, 1954).

Gypsum - The high moisture percentage is a 1:5 dilution (U.S. Salinity Laboratory Staff, 1954).

Gypsum requirement - Difference between Ca concentration of added gypsum solution and Ca+Mg Concentration in filtrate, as meq/liter, times 2 (U.S. Salinity Laboratory Staff, 1954).

Calcium carbonate equivalent - Back titration with 0.4N NaOH to neutralize 0.4N HCl remaining after boiling period. Two drops of phenolphthalien indicator are used (U.S. Salinity Laboratory Staff, 1954).

Organic carbon - The wet-combustion method of Walkley is used, and diphenylamine is the indicator (Walkley, 1947).

Cation exchange capacity - Determined by using 1.0N sodium acetate solution at pH 8.2 and 1.0N ammonium acetate at pH 7.0. Sodium determined by Perkin-Elmer Model 306 atomic absorption spectrophotometer.

LM-813 (Rev. 12/76)
Interior-Reclamation
Lower Missouri Region

Table Q-10
Results of Laboratory Tests on Auger Hole/Drill Hole Samples

GPO 838-860/28

Lab Number	(See last page of table) Site Number *	Depth Inches	Hydraulic Conductivity Ins./hr. 6th Hr.	Hydraulic Conductivity Ins./hr. 24th Hr.	pH 1:5	pH $CaCl_2$ .01M	Settling Volume ML	Lime Qual.	Gyp. Qual.	1:5 Extract ecx10³ @ 25 c	1:5 Extract Ca+Mg Me/L	1:5 Extract SAR Est.	1:5 Extract Ca+Mg Me/100g	Saturation Extract ecx10³ @ 25 c	Saturation Extract Na Me/L	Saturation Extract Ca+Mg Me/L	Saturation Extract SAR	Saturation Extract Sat %	Saturation Extract Ca+Mg Me 100g	Gyp Me 100g	Na Me/100g Total Na	Na Me/100g Exch. Na	Cation Exchange Capacity	ESP %	% of Moisture	% of Moisture 15 Bars
1	1-30-1	0-12	2.7	.88	7.4	6.3	14			.07													8.3			3.6
2	1-30-2	12-54	4.1	.56	9.2	7.0	14			.10													5.6			3.8
3	1-30-3	54-80	5.3	.58	9.7	7.2	14			.10													5.0			3.1
4	1-30-4	80-120	6.4	.64	9.7	7.4	14			.12													4.8			3.8
5	2-30-1	0-36	2.4	.22	9.2	7.5	16			.98				10.4	47	25.2	13.2	29.9					7.8			5.2
6	2-30-2	36-60	-	-	10.5	7.6	18			.38				2.6	23.2	1.0	32.8	35.1					7.6			6.2
7	4-30-1	0-24	5.4	.42	9.3	7.4	16			.08													5.2			3.5
8	4-30-2	24-60	0.5	-	10.5	7.9	19			.43				3.5	30.8	1.8	32.5	33.6					6.0			4.8
9	5-30-1	0-18	-	.54	8.5	7.8	16			1.1				8.1	37	24.4	10.6	26.3					14.2			3.3
10	5-30-2	18-48	-	-	9.5	7.6	15			.65				8.9	41	22.0	12.4	26.6					6.0			6.5
11	5-30-3	48-60	-	-	10.0	7.6	17			.60				9.4	46	18.6	15.1	47.8					9.0			6.9
12	6-30-1	0-24	3.4	1.1	9.1	7.4	16			.08													5.6			3.4
13	6-30-2	24-48	0.8	.98	9.0	6.8	16			.09													7.2			7.4
14	6-30-3	48-84	2.3	0.7	9.4	7.0	16			.11													5.6			3.9
15	6-30-4	84-120	13.4	1.2	9.6	7.1	16			.10													4.4			1.2
16	11-19-1	0-12	7.4	.46	9.2	7.2	15			.06													3.6			0.3
17	11-19-2	12-32	4.5	.48	9.2	7.4	16			.06													4.2			1.8
18	11-19-3	32-60	-	-	10.2	7.5	17			.21				1.4	12.4	.80	19.6	31.9					6.4			4.7
19	11-19-4	60-96	-	-	10.3	7.6	16			.33				3.6	26	2.0	26.0	31.8					5.2			4.1
20	11-19-5	96-120	-	-	9.7	8.2	155			.41				6.5	33	3.8	23.9	11.5					51.6			36.9
21	12-19-1	0-24	-	-	10.0	7.2	15			.30				2.7	23.2	3.0	18.9	28.1					7.2			4.9
22	12-19-2	24-46	-	-	10.1	7.4	15			.30				4.0	36	5.0	22.7	25.2					5.0			3.6
23	12-19-3	46-68	-	-	10.3	7.6	16			.36				2.2	18.4	1.2	23.8	40.8					5.6			6.3
24	12-19-4	68-100	-	-	10.3	7.7	18			.46				7.1	35	6.6	19.3	27.4					5.8			5.1
25	12-19-5	100-120	-	-	9.7	8.0	130			.28				10.4	51	15.8	18.1	84.7					21.6			1.8
26	16-25-1	0-12	-	-	9.8	7.6	17			.22				1.7	14.8	1.8	15.6	30.4					13.4			7.9
27	16-25-2	12-24	-	-	8.9	7.7	28			.86				6.0	25	18.0	8.3	49.9					25.8			14.6
28	16-25-3	24-36	-	-	9.1	7.5	36			.79				4.6	42	10.8	18.1	50.4					30.2			18.3
29	16-25-4	36-60	-	-	10.0	7.5	14			.50				3.4	28.8	4.2	19.9	30.6					6.2			2.2
30	17-25-2	12-54	1.2	.86	9.5	7.6	14			.09				.34	3.1	2.2	3.0	29.2					3.6			2.5
31	17-25-3	54-60	-	-	10.4	7.2	19			.25				2.6	24.4	1.2	31.5	30.5					6.6			7.8
32	18-25-1	0-12	-	-	9.0	7.6	29			1.1				8.4	72	23.0	21.2	45.5					23.8			15.1
33	18-25-2	12-24	-	-	9.6	7.5	20			.52				4.5	42	10.8	18.0	32.2					14.2			11.5
34	18-25-3	24-54	0.1	0.2	9.2	7.5	18			.87				6.1	48	16.8	16.6	27.0					9.0			4.2
35	18-25-4	54-60	0.2	-	8.6	7.6	19			1.2				7.8	72.8	17.4	24.7	28.2					14.4			7.3
36	20-30-1	0-10	3.1	.64	9.4	7.4	15			.14				1.1	7.2	3.0	5.9	26.9					7.8			
37	20-30-2	10-20	-	-	9.8	7.7	25			.58				6.1	47	4.6	31.0	37.6					16.8			10.9
38	20-30-3	20-54	0.8	.48	8.5	7.5	16			1.5				8.5	106	24.6	31.4	27.2					13.0			4.1
39	20-30-4	54-74	2.4	0.8	8.7	7.5	15			1.1				8.5	73	19.6	23.3	25.4					4.8			5.8
40	20-30-5	74-102	-	-	8.8	8.0	210			2.1				14.1	143	22.4	41.8	82.4					29.8			20.4
41	20-30-6	102-120	-	-	9.8	7.2	19			.78				11.1	105	14.4	23.2	27.4					7.0			2.2
42	21-25-1	0-10	-	-	9.0	7.6	26			.99				8.4	72	22.2	21.6	41.0					19.8			12.1
43	21-25-2	10-42	-	-	9.8	7.7	17			.45				4.8	44	7.0	23.5	26.6					10.0			4.9
44	21-25-3	42-72	-	-	9.7	7.5	18			.31				3.9	36	3.4	27.6	31.1					8.2			6.3
45	25-24-1	0-24	0.5	0.74	8.9	7.6	17			.09				.43	1.1	6.4	.59	24.4					10.6			8.0
46	25-24-2	24-54	0.4	.66	9.3	7.4	17			.13													9.4			5.0
47	25-24-3	54-84	2.0	1.4	9.1	7.7	18			.24													7.0			1.5
48	25-24-4	84-120	10.5	1.06	9.5	7.6	17			.13													4.2			2.4
49	28-26-1	0-12	1.7	.92	8.5	7.4	16			.04													7.4			3.5
50	28-26-2	12-66	.88	1.04	9.3	7.8	16			.08													3.8			3.6
51	28-26-3	66-84	5.3	0.9	9.4	7.8	15			.15													8.8			4.5
52	28-26-4	84-96	6.5	1.8	9.4	7.8	14			.09													3.8			0.9
53	31-23-1	0-18	.68	.86	8.6	7.6	19			.08													10.4			7.5
54	31-23-2	18-34	1.5	.98	9.4	7.8	19			.12													10.2			4.5
55	31-23-3	34-62	1.7	.64	9.6	7.9	18			.23													9.3			2.0
56	31-23-4	62-120	1.1	.48	9.5	7.8	17			.22													6.8			5.4
57	34-14-1	0-12	.02	-	10.0	7.9	16			.22				1.1	10.4	1.0	14.7	25.3					8.4			5.3
58	34-14-2	12-48	-	-	10.1	8.0	18			.31				2.0	17.2	1.4	20.5	26.9					4.2			3.9
59	34-14-3	48-72	-	-	9.7	8.2	91			.49				6.9	63.2	8.2	31.2	74.6					37.8			34.7
60	34-14-4	72-84	-	-	10.1	8.2	180			.32				3.5	27.6	3.6	20.6	80.9					18.8			26.2
61	35-14-1	0-16	3.8	.26	7.2	6.3	14			.04				.32	0.6	2.4	.55	26.6					4.2			1.9
62	35-14-2	16-60	3.8	4.0	8.9	6.9	15			.06				.30	1.6	1.6	1.79	25.9					3.2			5.9
63	38-14-1	0-24	3.1	.48	9.0	7.0	17			.06													7.0			3.4
64	38-14-2	24-54	5.2	.05	9.2	7.2	17			.07													5.2			2.6
65	38-14-3	54-90	.02	.02	9.5	7.4	20			.30				2.7	18.4	4.4	12.4	33.9					14.6			6.2
66	38-14-4	90-120	3.1	.48	8.8	7.2	17			.27				3.8	22	15.6	7.9	24.9					6.2			3.4

Table Q-10 (cont.)
Results of Laboratory Tests on Auger Hole/Drill Hole Samples

Lab Number	Site Number	Depth Inches	Hydraulic Conductivity Ins./hr. 6th Hr.	Hydraulic Conductivity Ins./hr. 24th Hr.	1:5 Extract pH 1:5	1:5 Extract pH $CaCl_2$ .01M	1:5 Extract Settling Volume ML	1:5 Extract Lime Qual.	1:5 Extract Gyp. Qual.	1:5 Extract ecx10^3 @ 25 c	1:5 Extract Ca+Mg Me/L	1:5 Extract SAR Est.	1:5 Extract Ca+Mg Me/100g	Saturation Extract ecx10^3 @ 25 c	Saturation Extract Na Me/L	Saturation Extract Ca+Mg Me/L	Saturation Extract SAR	Saturation Extract Sat %	Saturation Extract Ca+Mg Me 100g	Gyp Me 100g	Na Me/100g Total Na	Na Me/100g Exch. Na	Cation Exchange Capacity	ESP %	% of Moisture	% of Moisture 15 Bars
67	40-15-1	0-24	5.2	.50	9.1	7.3	15			.06													4.0			2.2
68	40-15-2	24-44	3.8	.46	9.2	7.4	16			.06													5.1			2.4
69	40-15-3	44-60	2.0	.40	9.4	7.4	17			.08													8.2			6.6
70	41-15-1	0-12	.80	.66	9.4	7.5	16			.14													7.8			4.3
71	41-15-2	12-44	.30	.20	9.7	7.6	17			.23													9.4			3.9
72	41-15-3	44-72	.02	-	10.0	6.9	16			.22				1.9	15.2	1.8	16.0	24.4					10.4			3.9
73	41-15-4	72-120	-	-	10.0	7.2	15			.24				2.1	16.8	1.4	20.1	25.6					5.6			3.3
74	44-11-1	0-12	-	-	9.6	7.7	26			.39				1.3	12.8	1.6	14.3	45.1					26.2			9.5
75	44-11-2	12-22	-	-	9.3	7.8	21			.59				4.2	31.6	8.8	15.1	36.8					14.8			13.8
76	44-11-3	22-48	-	-	9.8	7.8	75			.29				3.4	26	6.0	15.0	95.5					48.0			25.5
77	44-11-4	48-96	-	-	9.9	7.9	55			.30				1.7	12.8	1.6	14.3	90.5					60.0			37.7
78	45-11-1	0-24	.20	.06	8.9	7.6	27			.46				2.5	14.8	9.0	7.0	61.9					40.4			21.5
79	45-11-2	24-48	.52	.98	9.0	7.7	16			.31				2.8	14.4	10.8	5.4	31.1					6.8			6.2
80	45-11-3	48-72	1.6	.86	9.4	7.6	16			.21				1.9	38	6.6	20.9	26.7					5.2			6.8
81	47-22-1	0-4	-	-	9.7	7.1	21			.47				2.5	24.8	5.4	15.0	36.7					18.6			11.5
82	47-22-2	4-8	-	-	8.0	7.6	60			2.9				9.7	86	22.8	25.4	67.6					39.8			25.6
83	47-22-3	8-22	-	-	9.3	7.8	80			.93				8.5	67	16.6	23.3	82.0					48.0			29.6
84	47-22-4	22-36	-	-	10.2	8.0	250			.38				3.6	28.2	1.2	36.4	108.					35.8			37.7
85	47-22-5	36-48	-	-	10.3	8.2	290			.40				3.1	22.5	.80	35.6	122.					44.2			45.9
86	47-22-6	48-60	-	-	9.8	8.3	200			1.0				6.7	58	6.2	33.0	127.					59.4			34.8
87	47-22-7	60-70	-	-	9.7	8.1	355			.92				9.4	81	14.4	30.2	154.					88.0			42.7
88	47-22-8	70-102	-	-	9.4	8.0	198			.21				9.5	85	15.8	30.2	114.					60.8			39.2
89	48-22-1	0-10	1.6	.88	7.0	7.1	16			.05													9.2			2.6
90	48-22-2	10-24	1.0	.64	8.6	7.3	17			.09													9.4			4.4
91	48-22-3	24-72	6.4	.58	9.4	7.4	15			.09													5.4			2.8
92	48-22-4	72-120	4.3	.68	9.5	7.4	15			.09													5.0			2.1
93	51-22-1	0-10	.32	.30	9.3	7.5	19			.16													19.6			10.0
94	51-22-2	10-20	-	-	9.5	7.0	22			.35				1.9	13.1	1.8	55.2	13.8					12.8			3.8
95	51-22-3	20-48	-	-	8.2	7.3	21			1.0				5.6	37	18.4	12.2	27.3					11.8			6.9
96	51-22-4	48-72	3.2	.92	9.8	7.6	40			.34				1.8	11.5	5.2	28.5	7.1					39.6			30.7
97	53-24-1	0-30	1.4	1.3	9.1	7.4	22			.09													12.2			4.3
98	53-24-2	30-46	1.5	.68	9.3	7.5	16			.15													10.6			4.4
99	53-24-3	46-60	16.0	1.8	9.5	7.6	15			.14													8.8			2.1
100	55-10-1	0-8	2.3	.52	9.0	7.4	15			.05													4.2			1.8
101	55-10-2	8-36	-	-	9.9	6.9	16			.25				9.5									8.2			3.7
102	55-10-3	36-66	1.2	.64	8.5	7.0	16			.70				6.7	50	23.2	15.0	26.4					7.8			4.0
103	56-16-1	0-24	-	-	9.6	7.3	16			.54				6.0	54	13.2	21.0	23.9					7.6			3.7
104	56-16-2	24-48	-	-	8.8	7.5	120			.40				9.1	84	18.8	27.4	77.2					37.6			8.3
105	57-10-1	0-12	.90	1.4	8.1	7.2	17			.08													12.4			6.9
106	57-10-2	12-44	.28	.38	9.0	7.1	16			.09													12.2			3.5
107	57-10-3	44-60	17.0	5.2	9.2	7.3	16			.11													9.0			1.9
108	60-19-1	0-12	3.0	1.3	9.4	7.2	16			.09													9.2			2.1
109	60-19-2	12-24	-	-	9.8	7.3	16			.19				2.0	7.6	4.8	4.9	29.6					9.4			4.8
110	60-19-3	24-60	-	-	9.7	7.5	18			.45				5.5	50	12.6	19.9	31.3					13.6			5.3
111	61-19-1	0-12	.56	.76	9.2	7.5	17			.13				0.6	4.3	4.6	2.8	32.2					15.8			6.1
112	61-19-2	12-24	-	-	9.5	7.3	22			.38				2.7	19.6	5.0	12.4	38.2					19.6			6.7
113	61-19-3	24-60	.78	1.1	8.5	7.4	18			1.1				9.0	56	41.2	12.3	29.4					12.0			6.7
114	4 x B	Surf.	-	-	7.3	6.5	75			9.6				36.1	458.	164	50.7	64.8					37.0			18.7
115	62-7-1	0-24	.80	1.2	9.4	7.0	17			1.1				.71	4.9	2.0	4.9	27.2			1.0	.87	10.6	8.2		4.0
116	62-7-2	24-60	-	-	9.3	7.1	21			.25				1.9	14.4	3.8	10.4	33.7			2.6	2.1	14.6	14.4		6.3
117	62-7-3	60-102	-	-	9.9	7.1	17			.19				1.7	13.6	1.4	16.3	26.9			2.2	1.8	7.6	23.9		5.0
118	62-7-4	102-120	-	-	10.0	7.7	320			.37				7.5	68	15.6	24.4	84.3			12.6	6.9	31.6	21.8		20.8
119	63-8-1	0-24	-	-	9.7	7.2	18			.31				3.3	27.6	4.2	19.0	37.3					8.8			5.3
120	63-8-2	24-48	-	-	8.9	7.3	205			.80				8.2	71	18.0	23.7	62.3					40.8			17.4
121	64-8-1	0-20	5.4	.70	8.7	6.4	14			.07													4.2			3.3
122	64-8-2	20-54	12.0	1.1	9.6	7.0	15			.10													4.4			2.9
123	66-12-1	0-24	1.6	1.5	8.7	7.0	14			.09													9.6			3.5
124	66-12-2	24-48	.46	.62	9.4	7.4	17			.16													9.2			5.2
125	66-12-3	48-72	5.4	1.5	9.7	7.5	18			.21													5.4			1.9
126	66-12-4	72-108	16.0	5.4	9.8	7.6	17			.23													8.2			6.0
127	67-12-1	0-12	1.3	2.8	9.5	7.5	18			.19				1.1	9.2	1.4	11.0	27.8					13.8			6.4
128	67-12-2	12-38	-	-	9.8	7.6	16			.57				4.7	47.6	4.0	33.7	27.2					12.4			1.8
129	67-12-4	38-66	.36	.38	8.9	7.7	16			1.0				7.8	78	23.4	22.8	34.0					9.2			4.8
130	67-12-5	66-120	-	-	9.6	7.6	16			.61				8.1	69	14.4	25.7	27.8					6.8			6.3

LM-813 (Rev.12/76)
Interior - Reclamation
Lower Missouri Region

Table Q-10 (cont.)
Results of Laboratory Tests on Auger Hole/Drill Hole Samples

Lab Number	Site Number	Depth Inches	Hydraulic Conductivity Ins./hr. 6th Hr.	Hydraulic Conductivity Ins./hr. 24th Hr.	pH 1:5	pH $CaCl_2$ .01M	Settling Volume ML	Lime Qual.	Gyp. Qual.	1:5 Extract ecx10^3 @ 25 c	1:5 Extract Ca+Mg Me/L	1:5 Extract SAR Est.	1:5 Extract Ca+Mg Me/100g	Saturation Extract ecx10^3 @ 25 c	Saturation Extract Na Me/L	Saturation Extract Ca+Mg Me/L	Saturation Extract SAR	Saturation Extract Sat %	Saturation Extract Ca+Mg Me 100g	Gyp Me 100g	Na Me/100g Total Na	Na Me/100g Exch. Na	Cation Exchange Capacity	ESP %	% of Moisture	% of Moisture 15 Bars
131	68-7-1	0-34	-	-	9.7	6.9	16			.33				2.3	20	3.2	15.8	32.2					9.0			2.8
132	68-7-2	34-60	-	-	9.3	7.5	22			1.3				11.2	118	19.4	37.9	35.6					15.0			6.3
133	70-6-1	0-42	18.0	1.3	9.0	7.4	14			.08													3.8			1.0
134	70-6-2	42-60	13.0	.92	8.9	7.4	15			.08													4.4			0.2
135	72-5-1	0-28	-	-	9.4	7.5	17			.30				3.2	25.2	5.4	38.3	27.6					9.8			7.9
136	72-5-2	28-42	-	-	8.0	7.5	50			11.8				7.9	71	21.2	21.8	49.4					13.2			10.1
137	73-5-1	0-36	9.6	.96	8.9	7.5	15			.08													4.2			4.2
138	73-5-2	36-66	7.5	.66	9.3	7.6	15			.09													3.8			1.3
139	73-5-3	66-104	-	-	10.1	7.8	16			.50				3.7	29.6	1.4	35.4	32.6					6.8			26.6
140	73-5-4	104-120	-	-	10.2	7.9	26			.46				3.2	26.4	0.6	48.2	44.2					8.8			13.1
141	75-4-1	0-24	.46	.88	8.9	6.4	18			.17				1.4	8.8	4.0	6.2	32.9					13.0			6.9
142	75-4-2	24-46	.62	.20	8.5	6.8	21			.92				4.4	37.6	4.2	32.4	42.5					16.2			9.6
143	75-4-3	46-60	-	-	6.9	7.4	200			2.0				3.0	31.2	9.6	1.5	84.0					35.8			24.5
144	76-4-1	0-12	.42	1.0	8.6	7.3	20			.08				.41	2.0	1.8	2.2	37.9					19.8			11.0
145	76-4-2	12-48	.82	1.7	8.9	7.4	21			.52				4.0	26.0	19.0	8.4	43.1					16			13.3
146	76-4-3	48-60	2.7	2.2	7.8	7.2	17			.47				4.3	27.2	19.2	8.8	35.2					13			6.8
147	77-5-1	0-12	3.1	.86	8.1	7.1	18			.07													9.8			4.7
148	77-5-2	12-36	4.4	2.9	8.8	7.3	17			.09													12			8.6
149	77-5-3	36-60	5.5	1.0	9.3	7.5	16			.10													7.4			4.6
150	78-9-1	0-4	1.1	.92	9.1	7.5	17			.07													9.6			2.6
151	78-9-2	4-14	-	-	9.7	7.0	22			.47				.95	14.2	3.6	10.6	46.6					15			14.2
152	78-9-3	14-48	.32	.42	8.6	7.2	18			.94				8.0	58	28.6	15.3	32.3					12			6.0
153	78-9-4	48-60	-	-	10.1	7.4	16			.30				2.2	16	1.2	20.7	28.4					7.2			6.7
154	79-9-1	0-4	.06	.04	8.7	7.3	15			.08				0.7	4.3	1.8	4.5	21.3					6.6			3.3
155	79-9-2	4-24	-	-	9.5	7.5	22			.38				2.7	19.6	4.0	13.9	45.5					16			11.8
156	79-9-3	24-40	.04	-	8.4	7.6	23			1.6				7.2	49	29.0	12.9	48.7					20			10.3
157	79-9-4	40-60	-	-	9.3	7.5	17			.22				3.2	22.8	4.8	14.7	16.7					8.6			4.4
158	81-17-1	0-20	-	-	9.2	7.5	28			.46				2.4	18	3.2	14.2	44.8					19.4			14.6
159	81-17-2	20-60	-	-	7.9	7.5	43			1.9				6.3	43	25.4	12.1	69.1					37.2			46.4
160	82-17-1	0-12	1.5	1.8	8.3	7.4	18			.08													9.4			4.1
161	82-17-2	12-38	2.0	1.8	9.1	6.6	15			.09													8.4			3.7
162	82-17-3	38-120	11.8	4.1	9.4	6.9	15			.18													5.0			5.0
163	85-18-1	0-30	-	-	9.8	7.2	17			.40				4.2	57.2	11.4	24.0	27.9					11.0			8.0
164	87-7-1	0-24	6.3	.76	9.0	7.2	16			.07													7.2			3.3
165	87-7-2	24-60	3.9	2.2	9.1	7.3	17			.07													7.8			4.0
166	25-17-1	0-12	12.7	2.4	9.0	7.3	16			.06													3.6			0.1
167	8-30-1	0-48	2.9	.4	9.7	7.4	15			.11													5.8			3.2
168	8-30-2	48-82	-	-	10.3	7.6	17			.25				1.4	10.8	0.6	19.7	27.9					6.0			7.8
169	8-30-3	82-120	-	-	9.6	7.8	145			.35				4.1	40.5	2.8	34.2	81.1					28.6			24.9
170	9-30-1	0-54	8.6	.62	9.1	7.4	18			.08													5.8			2.7
171	9-30-2	54-108	10.2	.68	9.3	6.5	17			.11													6.6			2.4
172	10-30-1	0-36	-	-	9.5	7.0	18			.30				2.8	25.6	6.8	13.9	28.3					12.8			4.4
173	10-30-2	36-84	-	-	10.1	7.2	16			.16				1.0	8.8	1.6	9.8	27.1					4.2			4.0
174	10-30-3	84-116	-	-	10.2	7.5	19			.32				1.6	11.5	1.2	14.8	26.3					6.8			5.9
175	13-24-1	0-12	1.4	.60	9.3	7.3	17			.09				0.6	3.5	6.8	1.9	27.3					7.4			3.2
176	13-24-2	12-60	-	-	10.0	7.5	16			.34				2.6	22	8.6	10.6	29.0					4.4			2.7
177	13-24-3	60-96	-	-	9.2	7.8	78			1.1				7.9	80	15.8	28.5	57.1					21.2			20.5
178	14-25-1	0-8	-	-	9.9	7.6	17			.22				0.77	9.4	1.4	11.2	34.1					9.6			2.3
179	14-25-2	8-42	-	-	10.0	7.7	16			.24				1.8	13.6	1.6	15.2	27.5					6.6			3.6
180	14-25-3	42-64	-	-	9.9	7.6	15			.20				0.63	8.0	0.4	17.9	24.2					4.2			3.8

Table Q-10 (cont.)
Results of Laboratory Tests on Auger Hole/Drill Hole Samples

GPO 838-360/28

Lab Number	Site Number	Depth Inches	Hydraulic Conductivity Inc./hr. 6th Hr.	Hydraulic Conductivity Inc./hr. 24th Hr.	pH 1:5	pH $CaCl_2$ .01M	Settling Volume ML	Lime Qual.	Gyp. Qual.	1:5 Extract ecx10³ @ 25 c	1:5 Extract Ca+Mg Me/L	1:5 Extract SAR Est.	1:5 Extract Ca+Mg Me/100g	Saturation Extract ecx10³ @ 25 c	Saturation Extract Na Me/L	Saturation Extract Ca+Mg Me/L	Saturation Extract SAR	Saturation Extract Sat %	Saturation Extract Ca+Mg Me 100g	Gyp Me 100g	Na Me/100g Total Na	Na Me/100g Exch. Na	Cation Exchange Capacity	ESP %	% of Moisture	% of Moisture 15 Bars
181	15-25-1	0-12	8.4	1.5	7.9	6.3	16			.08				.56	1.8	5.4	1.1	28.2			.24	.19	7.0	2.7		3.0
182	15-25-2	12-36	-	-	9.5	6.9	16			.46				5.2	54.4	8.0	27.2	30.7			3.6	1.9	5.4	35.2		4.1
183	15-25-3	36-66	-	-	9.5	7.3	18			.77				6.7	71.0	7.6	36.4	34.9			6.2	3.7	14.8	25.0		4.3
184	15-25-4	66-94	-	-	9.2	7.7	34			1.2				12.2	112.0	22.6	33.3	36.4			12.0	7.9	24.2	32.6		9.6
185	19-30-1	0-36	3.1	1.4	9.0	7.6	27			.07													5.4			3.0
186	19-30-2	36-72	5.2	1.8	9.5	7.6	15			.08													4.6			2.3
187	19-30-3	72-114	-	-	10.2	7.8	17			.45				2.4	20.0	0.8	31.6	32.0					6.0			6.0
188	23-25-1	0-18	-	-	9.2	7.9	19			.64				6.5	57.0	22.2	17.1	32.4					14.8			5.5
189	23-25-2	18-46	.26	.14	8.8	7.8	16			.80				6.4	62.8	23.0	18.5	27.7					11.4			5.6
190	23-25-3	46-90	-	-	9.6	7.6	17			.22				4.5	45.6	9.0	21.5	30.2					6.0			5.0
191	23-25-4	90-114	-	-	9.8	6.7	18			.45				3.2	46.4	5.2	28.8	33.2					11.0			5.9
192	24-25-1	0-18	1.4	1.5	9.3	6.9	16			.11													8.8			3.8
193	26-24-1	0-24	.36	.36	8.0	6.9	18			.05													12.6			5.8
194	26-24-2	24-48	.18	.18	8.7	7.2	16			.75				.54	1.1	4.2	.76	17.5					8.4			3.6
195	26-24-3	48-70	1.8	.82	8.8	7.3	15			.06													4.8			0.6
196	26-24-4	70-120	7.6	1.6	8.6	7.1	15			.04													4.6			2.9
197	27-24-1	0-22	1.0	1.2	8.5	7.4	16			.08													10.8			5.6
198	27-24-2	22-60	7.5	2.1	9.0	7.5	14			.12													4.8			4.5
199	27-24-3	60-120	1.5	5.1	9.4	7.7	16			.09													5.0			3.5
200	29-27-1	0-12	2.7	2.9	6.9	7.4	15			.06				.38	0.65	3.1	.5	26.9			.16	.14	10.4	1.3		6.3
201	29-27-2	12-36	.36	.44	8.4	7.3	17			.15				.80	8.0	2.2	7.7	26.1			1.2	.99	10.6	9.3		6.8
202	29-27-3	36-82	.44	.70	9.0	7.8	15			.35				4.5	39.0	9.2	18.2	23.5			2.6	1.7	7.0	24.3		4.6
203	29-27-4	82-120	12.2	3.2	9.2	7.7	15			.23				3.3	26.0	13.3	10.1	21.5			1.2	.64	3.6	17.8		3.6
204	30-24-1	0-24	5.0	1.9	8.5	7.4	15			.05				.64	1.7	4.3	1.3	23.0			.12	.08	3.4	2.4		0.2
205	30-24-2	24-60	4.6	2.4	9.8	7.6	16			.09				.52	6.0	.78	9.6	28.4			1.4	1.2	3.4	35.1		9.5
206	33-13-1	0-8	-	-	9.5	7.7	18			.18				.85	6.9	1.2	8.9	32.5					10.0			5.5
207	33-13-2	8-34	-	-	8.6	7.7	17			.71				6.7	48.0	25.6	13.4	35.1					14.2			10.6
208	33-13-3	34-48	.18	.18	7.5	7.8	18			1.3				5.5	53.2	27.8	14.3	36.5					14.6			11.9
209	33-13-4	48-96	-	-	8.8	7.6	20			.65				4.3	36.0	17.4	12.2	40.5					21.0			14.0
210	33-13-5	96-120	.04	-	8.8	7.6	17			.45				3.5	26.8	16.8	9.2	30.3					15.4			8.5
211	36-14-1	0-12	14.7	1.5	8.9	6.9	14			.06													2.6			2.0
212	36-14-2	12-54	6.5	.52	8.4	7.3	15			.07													3.6			1.3
213	36-14-3	54-84	-	-	9.5	7.4	16			.21				2.6	13.5	17.2	4.6	31.8					4.8			4.3
214	36-14-4	84-120	-	-	10.1	7.7	20			.35				1.0	9.5	0.80	15.0	36.8					4.6			15.9
215	37-14-1	0-12	5.0	3.1	8.1	7.3	18			.06													5.6			2.7
216	37-14-2	12-32	.90	1.2	9.1	7.5	16			.11													5.8			15.5
217	37-14-3	32-48	-	-	9.6	7.8	18			.34				1.7	13.6	2.4	12.4	31.8					12.6			6.3
218	37-14-4	48-60	-	-	9.7	7.9	16			.25				2.0	16.8	2.2	16.0	26.2					5.8			6.4
219	37-14-5	60-74	-	-	9.8	8.2	92			.30				4.3	37.2	11.2	15.7	83.1					38.8			26.9
220	37-14-6	74-120	-	-	9.2	8.0	68			.50				3.1	25.2	6.8	13.7	78.8					52.0			38.4
221	39-15-1	0-12	-	-	9.5	7.5	23			.30				1.7	14.8	5.6	8.8	41.8					15.6			12.6
222	39-15-2	12-38	-	-	9.9	7.6	16			.23				1.4	11.4	5.0	7.2	31.5					4.2			3.0
223	39-15-3	38-78	-	-	10.1	7.7	16			.24				1.3	11.2	1.2	14.4	26.9					3.6			4.4
224	39-15-4	78-120	-	-	9.9	7.7	18			.22				1.0	9.6	3.2	7.6	25.5					3.4			4.9
225	46-23-1	0-8	5.4	1.9	8.5	7.3	18			.05													4.8			3.3
226	46-23-2	8-28	1.1	1.3	8.6	7.4	16			.09													6.8			12.7
227	46-23-3	28-60	4.7	1.3	9.1	6.7	14			.09													3.4			2.0
228	46-23-4	60-120	255.	4.6	9.2	7.0	15			.09													2.0			4.0
229	54-10-1	0-14	-	-	9.0	7.3	19			.53				4.2	30.8	14.2	11.6	35.9					11.8			10.6
230	54-10-2	14-42	-	-	8.8	7.4	37			.84				7.3	59.0	29.0	15.4	49.4					27.4			18.6
231	54-10-3	42-66	-	-	9.3	6.2	15			.29				2.5	29.6	0.80	46.8	25.1					5.6			4.9
232	54-10-4	66-120	.04	.08	9.8	7.1	18			.27				1.7	14.8	4.0	10.5	30.3					8.0			1.6
233	58-16-1	0-6	-	-	9.5	7.4	17			.46				3.1	30.8	17.4	10.4	27.2			4.2	3.4	9.4	36.1		7.3
234	58-16-2	6-48	1.0	-	9.0	7.4	18			.64				6.0	42.0	18.0	14.0	22.4			3.4	2.5	7.0	35.7		3.7
235	58-16-3	48-84	-	-	9.7	7.5	18			.38				3.4	29.2	4.8	18.8	20.9			3.4	2.8	7.2	38.8		4.6
236	58-16-4	84-120	-	-	9.7	7.5	17			.42				3.4	27.2	5.2	16.9	24.9			3.6	2.9	8.0	36.2		2.1
237	59-16-1	0-24	.82	.92	9.1	7.4	16			.10													8.4			4.8
238	59-16-2	24-48	1.9	2.4	9.6	7.4	16			.14													6.4			3.5
239	69-6-1	0-24	2.0	2.4	8.9	7.4	15			.10													9.2			4.8
240	69-6-2	24-60	.40	.50	9.2	7.7	17			.25													9.6			6.7
241	69-6-3	60-120	2.7	1.3	8.8	6.0	16			.24													7.0			8.4
242	71-7-1	0-30	15.5	1.1	8.6	6.1	14			.06													4.4			1.7
243	71-7-2	30-60	-	-	9.7	6.4	17			.60				3.5	37.6	4.0	26.6	36.3					10.6			9.4

LM-813 (Rev.12/76)
Interior-Reclamation
Lower Missouri Region

Table Q-10 (cont.)
Results of Laboratory Tests on Auger Hole/Drill Hole Samples

GPO 886-860/20

Lab Number	Site Number	Depth Inches (AH) Feet (DH)	Hydraulic Conductivity Ins./hr. 6th Hr.	Hydraulic Conductivity Ins./hr. 24th Hr.	pH 1:5	pH $CaCl_2$ .01M	Settling Volume ML	Lime Qual.	Gyp. Qual.	1:5 Extract ecx10^3 @ 25 c	1:5 Extract Ca+Mg Me/L	1:5 Extract SAR Est.	1:5 Extract Ca+Mg Me/100g	Saturation Extract ecx10^3 @ 25 c	Saturation Extract Na Me/L	Saturation Extract Ca+Mg Me/L	Saturation Extract SAR	Saturation Extract Sat %	Saturation Extract Ca+Mg Me 100g	Gyp Me 100g	Na Me/100g Total Na	Na Me/100g Exch. Na	Cation Exchange Capacity	ESP %	% of Moisture	15 Bars
244	74-5-1	0-48	-	-	7.8	6.1	50		.80					8.0	71.0	13.2	14.6	62.4					57.6			28.3
245	80-16-1	0-18	.72	.88	8.1	5.9	18		.07					.43	17.0	3.1	1.4	26.1			.28	.24	13.2	1.8		7.2
246	80-16-2	18-36	.20	.22	8.9	6.2	17		.14					.53	47.0	1.6	5.3	26.0			1.5	1.4	14.8	9.5		7.6
247	80-16-3	36-60	10.0	3.0	9.1	6.6	16		.22					3.0	21.0	10.2	9.3	17.5			1.8	1.4	10.4	13.5		2.8
248	80-16-4	60-96	9.6	2.3	8.9	6.7	17		.22					3.6	20.0	22.6	6.0	20.7			.98	.57	4.0	14.3		2.7
249	80-16-5	96-120	7.0	1.4	9.1	6.8	16		.12					.88	6.6	1.8	7.0	22.3			.62	.47	7.0	6.7		3.1
250	84-18-1	0-20	3.1	2.7	7.8	6.8	17		.06														11.0			5.6
251	84-18-2	20-40	3.0	1.9	8.4	5.9	15		.08														7.4			5.5
252	84-18-3	40-66	.44	.50	9.1	6.5	16		.16														9.6			7.1
253	84-18-4	66-84	.30	.26	9.1	6.9	17		.36														13.8			6.0
254	84-18-5	84-104	7.4	1.9	8.6	7.1	16		.47														6.6			4.0
255	84-18-6	104-112	13.5	4.4	9.3	7.2	16		.39														4.2			0.5
256	84-18-7	112-120	-	-	9.6	7.4	14		.39					1.3	9.4	1.6	10.5	36.4					24.0			13.1
257	86-7-1	0-8	-	-	9.7	7.5	16		.53					1.6	13.4	0.8	21.2	28.3					7.8			3.5
258	88-17-1	0-20	-	-	9.6	7.5	17		.50					5.0	38.0	11.0	16.2	27.9					7.6			3.5
259	*DH.1-1	14.8-22.8	-	-	5.7	5.1	50		.79					7.3	66.0	12.0	26.9	59.6					40.0			24.9
260	DH.1-2	33.8-40.8	-	-	10.0	8.5	180		.41					1.1	9.8	0.6	17.9	109.5					35.0			56.8
261	DH.1-3	53.9-62.2	-	-	9.8	8.8	300		.91					1.1	11.4	0.6	20.8	91.6					51.2			52.1
262	DH.1-4	67.7-81.9	-	-	9.5	7.7	50		.37					1.0	8.4	1.0	11.9	50.8					7.2			6.7
263	DH.1-5	85.1-94.5	-	-	9.6	7.6	60		.56					1.2	11.1	1.4	13.3	46.6					14.2			21.9
264	DH.1-6	101.1-116.1	-	-	9.7	8.3	160		.70					1.2	10.3	1.4	12.3	99.7					39.8			43.1
265	DH.1-7	129.8-147.8	-	-	9.6	8.4	175		.29					1.0	10.0	1.2	12.9	90.7					13.0			12.1
266	DH.1-8	147.8-157.8	-	-	9.6	8.6	275		.67					1.3	12.9	0.4	28.8	93.0					14.4			30.6
267	DH.1-9	161.0-180.5	-	-	10.0	9.0	440		.76					1.3	13.2	0.6	24.1	161.2					43.4			64.8
268	DH.1-10	180.5-192.5	-	-	9.9	8.6	175		.73					2.0	18.6	0.2	58.8	105.8					37.4			42.5
269	DH.1-11	199.6-221.0	-	-	9.6	7.7	42		.70					5.1	68.0	4.0	48.1	45.9					11.6			7.1
270	DH.1-12	221.0-236.5	-	-	9.8	8.6	160		.80					2.2	28.4	0.4	63.5	78.9					31.6			27.0
271	DH.1-13	241.8-255.0	-	-	9.9	7.5	90		.76					3.5	46.0	0.6	83.9	68.7					28.2			43.8
272	DH.1-14	260.5-280.5	-	-	9.7	8.0	95		.95					4.8	60.8	1.0	85.9	70.8					25.6			38.2
273	DH.1-15	280.5-300.5	-	-	9.7	8.0	50		.59					4.6	76.0	5.0	48.1	57.0					38.2			31.8
274	DH.2-1	2.0-22.5	-	-	9.1	7.6	50		1.1					8.6	79.0	14.0	29.9	71.7					38.4			20.9
275	DH.2-2	22.5-32.6	-	-	9.5	7.4	225		.27														28.0			35.1
276	DH.2-3	32.6-56.7	-	-	9.1	7.5	75		.85					3.9	54.0	2.0	54.0	96.1					42.4			45.7
277	DH.2-4	63.0-77.8	-	-	9.8	7.7	57		.55														22.4			47.5
278	DH.2-5	77.8-89.6	-	-	10.0	7.7	88		.54					1.2	12.0	1.0	17.0	85.5					19.2			29.8
279	DH.2-6	108.4-118.5	-	-	9.6	8.0	120		.49														40.6			36.1
280	DH.2-7	121.7-132.7	-	-	9.5	8.1	110		.52					2.1	22.4	0.6	40.9	89.9					36.0			33.6
281	DH.2-8	137.4-150.9	-	-	9.9	8.5	125		.91					1.5	14.5	1.0	20.5	11.9					35.0			54.2
282	DH.2-9	175.4-186.1	-	-	10.1	8.0	45		.49					1.7	15.4	1.0	21.8	54.0					15.6			23.7
283	DH.2-10	188.4-196.2	-	-	10.0	8.6	175		.77					2.0	21.3	0.8	33.7	95.4					33.0			45.3
284	DH.2-11	211.5-225.0	-	-	10.2	8.4	200		.80					2.1	21.8	0.2	68.9	97.3					19.4			61.1
285	DH.3-1	9.0-14.5	-	-	9.2	7.9	50		.88					9.0	86.0	14.6	31.8	69.8					36.0			35.4
286	DH.3-2	14.5-26.4	-	-	9.2	7.9	50		.90					8.2	72.0	16.8	24.8	57.3					23.6			22.8
287	DH.3-3	26.6-33.0	-	-	9.7	7.9	70		.75														50.2			46.4
288	DH.3-4	33.6-49.4	-	-	9.8	8.4	54		.62														28.2			41.8
289	DH.3-5	54.5-65.6	-	-	9.8	8.3	38		.77														18.4			40.1
290	DH.3-6	65.6-93.3	-	-	9.4	8.2	60		.80														33.6			37.4
291	DH.3-7	93.3-118.5	-	-	9.5	8.1	80		.77														34.0			42.4
292	DH.3-8	118.5-134.0	-	-	10.2	8.4	70		.69														18.4			35.4
293	DH.3-9	143.2-154.3	-	-	10.0	8.8	210		.86														16.8			49.0
294	DH.3-10	154.3-161.8	-	-	10.1	8.7	200		.54														16.8			45.6
295	DH.3-11	169.8-176.5	-	-	10.0	8.5	140		.65														28.6			44.7
296	DH.3-12	177.2-190.6	-	-	9.9	8.2	75		.58														21.0			35.5
297	DH.3-13	199 0-206.3	-	-	9.8	7.9	20		.34														3.8			3.8
298	DH.3-14	223.8-252.8	-	-	10.2	8.8	310		.60														18.8			55.3
299	DH.4-1	33.5-41.0	-	-	8.5	7.7	43		.24														38.4			23.8
300	DH.4-2	41.0-45.7	-	-	8.5	7.4	34		.25														31.0			21.0
301	DH.4-3	48.0-55.0	-	-	7.9	6.9	28		.47														43.6			23.2
302	DH.4-4	55.0-71.6	-	-	9.2	7.8	45		.59														31.8			37.8
303	DH.4-5	71.6-81.5	-	-	9.2	7.7	21		.30														9.4			6.9
304	DH.4-6	81.5-94.5	-	-	9.5	8.2	43		.45														29.0			46.2
305	DH.4-7	94.8-105.5	-	-	9.0	8.4	50		.65														42.2			42.0

* See last page of table.

LM-813 (Rev.12/76)
Interior - Reclamation
Lower Missouri Region

Table Q-10 (cont.)
Results of Laboratory Tests on Auger Hole/Drill Hole Samples

GPO 838 - 360/20

Lab Number	Site Number	Depth Inches	Hydraulic Conductivity Inc./hr. 6th Hr.	Hydraulic Conductivity Inc./hr. 24th Hr.	pH 1:5	pH $CaCl_2$ .01M	Settling Volume ML	Lime Qual.	Gyp. Qual.	1:5 Extract ecx10^3 @ 25 c	1:5 Extract Ca+Mg Me/L	1:5 Extract SAR Est.	1:5 Extract Ca+Mg Me/100g	Saturation Extract ecx10^3 @ 25 c	Saturation Extract Na Me/L	Saturation Extract Ca+Mg Me/L	Saturation Extract SAR	Saturation Extract Sat %	Saturation Extract Ca+Mg Me 100g	Gyp Me 100g	Na Me/100g Total Na	Na Me/100g Exch. Na	Cation Exchange Capacity	ESP %	% of Moisture	% of Moisture 15 Bars
306	DH.4-8	107.0-112.3	-	-	9.2	8.5	55		.61														36.2			29.8
307	DH.4-9	126.8-134.4	-	-	9.3	8.4	59		.58														41.2			45.1
308	DH.4-10	134.4-144.0	-	-	9.4	8.3	37		.56														19.8			40.4
309	DH.4-11	144.0-152.2	-	-	9.5	8.5	76		.48														36.8			49.5
310	DH.4-12	154.1-160.8	-	-	9.5	8.3	68		.39														26.6			37.7
311	DH.4-13	191.3-198.2	-	-	9.8	8.7	150		.49														33.0			47.0
312	DH.4-14	206.7-218.2	-	-	9.8	7.7	19		.24														1.6			1.2
313	DH.4-15	225.9-233.0	-	-	10.0	9.1	200		.75														35.0			37.9
314	DH.4-16	233.0-239.5	-	-	10.0	8.8	50		.58														15.6			29.8
315	DH.4-17	245.6-250.0	-	-	10.0	9.2	120		.83														22.4			38.9
316	DH.6-1	1.5-14.0	-	-	7.1	6.0	50		.29														35.8			26.1
317	DH.6-2	14.0-27.2	-	-	6.5	6.1	60		1.0														38.2			31.5
318	DH.6-3	27.2-37.0	-	-	9.6	8.1	65		.58														37.6			32.3
319	DH.6-4	39.7-47.0	-	-	9.8	8.4	48		.69														16.8			54.7
320	DH.6-5	64.4-82.0	-	-	10.0	8.0	24		.59														12.8			28.2
321	DH.6-6	84.8-95.0	-	-	9.6	7.7	45		.53														40.2			33.6
322	DH.6-7	95.0-114.0	-	-	9.4	8.3	45		.66														36.0			42.9
323	DH.6-8	126.2-135.6	-	-	10.0	7.8	31		.55														11.4			24.8
324	DH.6-9	135.6-146.8	-	-	9.7	8.4	45		.66														33.2			55.5
325	DH.6-10	146.8-153.0	-	-	10.0	8.3	75		.58														14.8			45.4
326	DH.6-11	157.4-161.0	-	-	9.8	8.5	50		.61														34.0			41.5
327	DH.6-12	171.0-181.6	-	-	9.8	8.2	63		.57														25.6			37.3
328	DH.6-14	186.6-199.2	-	-	9.8	8.3	72		.60														31.0			42.7
329	DH.6-15	204.3-214.0	-	-	9.6	8.4	65		.76														30.8			45.7
330	DH.6-16	258.8-271.1	-	-	10.0	9.0	91		.70														30.2			61.9
331	DH.6-17	288.0-303.4	-	-	10.1	7.3	130		.65														11.2			48.3
332	DH.6-18	307.4-312.6	-	-	8.9	7.4	39		.50														4.2			7.0
333	DH.6-19	313.2-337.5	-	-	10.0	8.9	115		.56														26.8			53.3
334	DH.6-20	337.5-350.0	-	-	10.3	8.7	110		.62														13.2			43.8
335	DH.7-1	30.0-40.2	-	-	9.2	8.1	75		.93														41.8			37.8
336	DH.7-2	44.8-55.9	-	-	9.7	8.3	250		.26														45.0			24.5
337	DH.7-3	60.8-68.0	-	-	9.8	8.4	77		.62														27.0			48.4
338	DH.7-4	74.2-94.8	-	-	9.8	8.6	105		.76														42.6			82.3
339	DH.7-5	94.8-111.7	-	-	10.1	8.3	33		.58														16.2			32.6
340	DH.7-6	111.7-119.8	-	-	9.7	8.5	80		.72														36.4			36.4
341	DH.7-7	129.2-141.0	-	-	9.3	7.7	83		.50														30.0			45.0
342	DH.7-8	179.4-201.9	-	-	9.4	8.9	260		.69														29.0			45.0
343	DH.7-9	201.9-226.5	-	-	9.7	9.0	400		.60														26.6			36.5
344	DH.7-10	237.0-271.1	-	-	9.3	8.9	130		.39														30.0			38.1
345	DH.7-11	271.3-292.0	-	-	9.7	8.6	230		.52														15.2			17.4
346	DH.8-1	84.7-91.7	-	-	9.3	8.0	37		.54														14.6			27.6
347	DH.8-2	93.7-103.9	-	-	9.5	8.3	79		.58														17.4			53.7
348	DH.8-3	103.9-128.0	-	-	9.4	8.3	78		.54														28.4			44.7
349	DH.8-4	128.0-140.0	-	-	9.5	8.5	120		.59														34.6			48.0
350	DH.8-5	140.0-161.5	-	-	9.4	8.4	67		.60														35.0			27.4
351	DH.8-6	161.5-181.7	-	-	9.5	8.4	90		.56														36.0			39.1
352	DH.8-7	181.7-191.4	-	-	9.7	6.9	24		.32														7.4			5.9
353	DH.8-8	191.4-241.2	-	-	9.9	6.9	160		.50														32.4			35.1
354	DH.8-9	244.2-271.0	-	-	10.0	8.4	75		.55														8.6			10.6
355	DH.8-10	277.7-286.8	-	-	10.0	9.1	400		.61														26.0			42.6
356	DH.8-11	290.2-295.0	-	-	9.9	8.9	380		.37														29.6			42.1
357	DH.9-1	70.0-79.9	-	-	9.7	8.0	61		.34														23.2			35.2
358	DH.9-2	79.9-86.3	-	-	9.8	8.8	81		.29														30.2			44.7
359	DH.9-3	91.8-107.8	-	-	10.0	8.9	140		.68														41.8			31.5
360	DH.9-4	107.8-129.8	-	-	10.1	8.5	110		.49														17.8			34.3
361	DH.9-5	130.2-156.6	-	-	9.9	8.8	100		.61														41.6			38.8
362	DH.9-6	156.6-173.0	-	-	10.0	8.7	120		.60														16.8			37.7
363	DH.9-7	191.6-197.7	-	-	9.8	8.9	125		.34														31.0			54.4
364	DH.9-8	206.0-214.5	-	-	9.9	9.0	65		.60														23.2			45.4
365	DH.9-9	217.7-239.3	-	-	9.9	8.6	115		.60														12.2			41.1
366	DH.9-10	246.6-273.1	-	-	10.0	8.5	40		.46														6.8			7.8
367	DH.9-11	285.6-305.1	-	-	10.1	9.0	92		.70														17.2			28.7
368	DH.9-12	305.1-325.1	-	-	10.0	8.8	130		.61														13.8			38.2
369	DH.9-13	325.9-335.1	-	-	10.1	9.2	165		.48														32.2			34.2

LM-813 (Rev.12/76)
Interior - Reclamation
Lower Missouri Region

Table Q-10 (cont.)
Results of Laboratory Tests on Auger Hole/Drill Hole Samples

GPO 838-860/29

Lab Number	Site Number	Depth * Inches	Hydraulic Conductivity Inc./hr. 6th Hr.	Hydraulic Conductivity Inc./hr. 24th Hr.	pH 1:5	pH $CaCl_2$ .01M	Settling Volume ML	Lime Qual.	Gyp. Qual.	1:5 Extract ecx10^3 @ 25 c	1:5 Extract Ca+Mg Me/L	1:5 Extract SAR Est.	1:5 Extract Ca+Mg Me/100g	Saturation Extract ecx10^3 @ 25 c	Saturation Extract Na Me/L	Saturation Extract Ca+Mg Me/L	Saturation Extract SAR	Saturation Extract Sat %	Saturation Extract Ca+Mg Me 100g	Gyp Me 100g	Na Me/100g Total Na	Na Me/100g Exch. Na	Cation Exchange Capacity	ESP %	% of Moisture	% of Moisture 15 Bars
370	DH.5-1	21.5-25.0	-	-	7.9	8.0	170		1.31														54.2			29.1
371	DH.5-2	58.0-61.0	-	-	10.2	8.3	50		.48														12.8			34.6
372	DH.5-3	125.0-128.0	-	-	10.2	8.7	45		.69														28.2			29.4
373	DH.10-1	24.0-29.5	-	-	9.2	8.1	75		.37														40.0			38.9
374	DH.10-2	42-46	-	-	9.1	8.0	98		.42														42.4			38.5
375	DH.10-3	69-73	-	-	10.3	8.9	150		.60														18.6			10.2
376	DH.10-4	83-86	-	-	10.1	9.3	160		.81														46.2			37.1
377	DH.10-5	97-101	-	-	10.3	8.7	52		.68														9.6			40.8
378	DH.10-6	104-107	-	-	10.1	9.3	245		1.31														54.6			43.1
379	DH.10-7	153-157	-	-	10.3	9.4	95		.65														26.6			37.3
380	DH.10-8	173-176	-	-	10.1	8.8	44		.43														11.4			16.6
381	DH.10-9	186-189	-	-	10.2	8.9	105		.62														34.4			38.7
382	DH.10-10	195-198	-	-	10.1	8.5	65		.36														8.6			14.3
383	DH.10-11	212-216	-	-	9.1	8.0	47		.73														9.8			12.1
384	DH.10-12	217-220	-	-	10.3	7.8	100		.94														41.0			45.1
385	DH.10-13	227-230	-	-	10.1	8.4	200		.43														12.3			36.6
386	DH.10-14	240-243	-	-	10.4	9.6	150		.86														34.8			46.9
387	DH.10-15	254-258	-	-	10.0	9.0	140		.59														12.4			31.7
388	DH.10-16	316-329	-	-	9.8	8.8	210		.66														13.8			31.9
389	DH.10-17	438-441	-	-	10.3	9.2	175		.78														40.8			39.1

* 1-30-1
- 1 — Auger Hole No. (Profile No.)
- 30 — Section No.
- 1 — Sample No.

DH.1-1
- DH.1 — Drill Hole No.
- 1 — Sample No.

Table Q-11
Mechanical Analysis of Soil Samples
Kimbeto Study Site, New Mexico

Lab Number	Profile Number *	Depth in Inches	Lab Texture	Particle Size Distribution			Field Texture
				Sand	Silt	Clay	
1	1-30-1	0-12	LS-SL	81.0	7.6	11.4	SL
2	2	12-54	LS	81.0	10.6	9.4	LfS
3	3	54-80	LS	85.6	6.0	8.4	LfS
4	4	80-120	LS	85.0	3.6	11.4	LfS
5	2-30-1	0-36	LS	77.0	18.2	4.8	LS
6	2	36-60	SL	77.8	11.8	10.4	LS
7	4-30-1	0-24	LS	85.2	10.0	4.8	LfS
8	2	24-60	LS	83.8	9.8	6.4	LS
9	5-30-1	0-18	SL	67.4	10.0	12.6	LfS
10	2	18-48	S	91.2	0.4	8.4	S
11	3	48-60	S	90.0	7.6	2.4	S
12	6-30-1	0-24	S	88.8	4.8	6.4	LS
13	2	24-48	SL	69.4	20.2	10.4	SL
14	3	48-84	LS	82.8	12.8	4.4	LfS
15	4	84-120	S	91.4	3.2	5.4	S
16	11-19-1	0-12	LS	87.6	9.0	3.4	fS
17	2	12-32	LS	82.2	13.4	4.4	fS
18	3	32-60	LS	82.4	10.2	7.4	fS
19	11-19-4	60-96	LS	80.2	15.4	4.4	fS
20	5	96-120	CL	25.0	36.0	39.0	SS & Sh
21	12-19-1	0-24	SL	68.6	23.0	8.4	fS
22	2	24-46	LS	84.8	8.8	6.4	S
23	3	46-68	LS	81.8	13.8	4.4	fS
24	4	68-100	LS-S	87.6	7.0	5.4	S
25	5	100-120	SL	69.4	12.2	18.4	SS
26	16-25-1	0-12	CL	40.4	29.2	30.4	CL
27	2	12-24	CL	39.4	24.2	36.4	C
28	3	24-36	C	32.0	26.6	41.4	C
29	4	36-60	LS	83.4	10.2	6.4	fS
30	17-25-2	12-54	S	90.0	4.6	5.4	fS
31	3	54-60	LS	78.6	13.8	7.6	L
32	18-25-1	0-12	CL	34.4	26.0	39.6	CL
33	2	12-24	SL	62.4	12.0	15.6	LS
34	3	24-54	LS	81.8	9.6	8.6	S
35	4	54-60	SL	90.0	17.2	12.8	SL
36	20-30-1	0-10	SL	74.0	15.2	14.8	LS
37	20-30-2	10-20	SLL	53.6	25.6	20.8	CL
38	3	20-54	SL	76.8	12.4	10.8	LS
39	4	54-74	S	92.6	1.6	5.8	S
40	5	74-102	C	25.0	18.4	56.6	SC
41	6	102-120	LS	83.0	9.4	7.6	LS
42	21-25-1	0-10	SCL	48.4	21.0	30.6	CL
43	2	10-42	SCL	74.8	1.4	23.8	fS
44	3	42-72	LS	83.2	8.2	8.6	fS
45	25-24-1	0-24	SL	63.0	25.2	11.8	L
46	2	24-54	SL	72.0	17.2	10.8	SL
47	3	54-84	LS	84.6	6.6	8.8	LS
48	4	92-120	S	89.8	6.4	3.8	S
49	28-26-1	0-12	LS	75.8	3.4	10.8	SL
50	2	12-66	S	90.2	4.0	5.8	fS
51	3	66-84	SL	77.4	12.8	9.8	L
52	4	84-96	SL	70.4	24.8	4.8	S
53	31-23-1	0-18	SL	56.4	25.8	17.8	L
54	2	18-34	LS	82.4	6.8	10.8	LfS
55	31-23-3	34-62	LS	83.0	7.2	9.8	LfS
56	4	62-120	LS	82.4	10.8	6.8	fS
57	34-14-1	0-12	SL	78.4	10.0	11.6	LS
58	2	12-48	LS	84.2	9.2	6.6	fS
59	3	48-72	C	14.4	33.0	52.6	Sh
60	4	72-84	SCL	49.6	27.8	22.6	SS
61	35-14-1	0-16	LS	85.8	11.2	3.0	fS
62	2	16-60	LS	82.4	14.6	3.0	fS

* 1-30-1
- 1 — Auger Hole No. (Profile No.)
- 30 — Section No.
- 1 — Sample No.

DH.1-1
- 1 — Drill Hole No.
- 1 — Sample No.

Table Q-11(con.)
Mechanical Analysis of Soil Samples
Kimbeto Study Site, New Mexico

Lab Number	Profile Number	Depth in inches	Lab Texture	Particle Size Distribution			Field Texture
				Sand	Silt	Clay	
63	38-14-1	0-24	LS-SL	78.6	12.6	8.8	LfS
64	2	24-54	LS	84.6	9.6	5.8	fS
65	3	54-90	SL	53.2	27.8	19.0	CL
66	4	90-120	LS	84.8	9.2	6.0	fS
67	40-15-1	0-24	S	89.8	7.0	3.2	fS
68	2	24-44	LS	86.0	9.8	4.2	fS
69	3	44-60	SL	74.2	20.6	5.2	LfS
70	41-15-1	0-12	SL	71.4	19.6	9.0	LfS
71	2	12-44	SL	70.4	20.6	9.0	LfS
72	3	44-72	LS	84.4	12.4	3.2	fS
73	41-15-4	72-120	LS	82.2	12.6	5.2	fS
74	44-11-1	0-12	CL	36.0	31.0	33.0	C
75	2	12-22	SCL	59.2	18.8	22.0	CL
76	3	38-48	C	27.2	19.8	53.0	C
77	4	48-96	C	26.6	28.2	45.2	Sh
78	45-11-1	0-24	C	37.6	16.2	46.2	C
79	2	24-48	SCL	62.2	4.6	33.2	L
80	3	48-72	SL	74.0	15.0	11.0	SL
81	47-22-1	0-4	SCL	50.8	20.2	29.0	SCL
82	2	4-8	C	26.8	22.2	51.0	C
83	3	8-22	C	14.0	39.0	47.0	C
84	4	22-36	CL	35.4	25.6	39.0	C
85	5	36-48	C	31.6	21.4	47.0	Sh
86	6	48-60	C	22.0	21.2	56.8	Sh
87	7	60-70	C	44.2	10.0	45.8	Sh
88	8	70-102	C	16.6	18.4	65.0	Sh
89	48-22-1	0-10	SL	69.6	23.4	7.0	SL
90	2	10-24	SL	70.4	19.6	10.0	L
91	48-22-3	24-72	LS	83.2	12.4	4.4	LfS
92	4	72-120	S	92.0	3.6	4.4	fS
93	51-22-1	0-10	L	41.4	32.2	26.4	CL
94	2	10-20	CL	44.4	28.2	27.4	C
95	3	20-48	SL	79.0	7.6	13.4	SL
96	4	48-72	C	13.6	31.0	55.4	Sh
97	53-24-1	0-30	SL	62.4	25.2	12.4	L
98	2	30-46	SL	71.8	15.8	12.4	SL
99	3	46-60	S	70.4	23.0	6.6	S
100	55-10-1	0-8	LS	84.0	11.6	4.4	fS
101	2	8-36	LS	84.0	7.6	8.4	SL
102	3	36-66	LS	83.5	6.1	10.4	fS
103	56-16-1	0-24	LS	84.8	6.6	8.6	L
104	2	24-48	LL	20.8	42.8	36.4	Sh
105	57-10-1	0-12	SL	64.0	23.6	12.4	L
106	2	12-44	SL	60.6	26.8	12.6	L
107	3	44-60	S-LS	89.4	2.2	8.4	S
108	60-19-1	0-12	SL	73.8	15.6	10.6	LfS
109	60-19-2	12-24	SL	74.2	15.2	10.6	SL
110	3	24-60	SL	73.0	15.4	11.6	LfS
111	61-19-1	0-12	L	46.2	37.4	16.4	L
112	2	12-24	L	39.2	39.4	21.4	CL
113	3	24-60	L	50.6	34.0	15.4	L
114	4 x B	surface	L	21.2	34.4	44.4	C
115	62-7-1	0-24	SL	72.0	18.6	9.4	LfS
116	2	24-60	L	51.4	32.0	16.6	L
117	3	60-102	LS	84.4	9.2	6.4	S
118	4	102-120	LL	34.4	37.2	28.4	Sh
119	63-8-1	0-24	SL	74.4	17.2	8.4	LfS
120	2	24-48	CL	30.2	41.4	28.4	SS & Sh
121	64-8-1	0-20	S	86.8	10.2	2.0	fS
122	2	20-54	LS	85.6	11.4	3.0	fS
123	66-12-1	0-24	SL	68.8	19.2	12.0	SL
124	2	24-48	SL	72.2	12.8	15.0	SL
125	3	48-72	S	90.8	1.2	8.0	fS
126	4	72-108	S-LS	89.0	3.0	8.0	S

Table Q-11 (con.)
Mechanical Analysis of Soil Samples
Kimbeto Study Site, New Mexico

Lab Number	Profile Number	Depth in inches	Lab Texture	Particle Size Distribution			Field Texture
				Sand	Silt	Clay	
127	67-12-1	0-12	SL	75.8	14.0	10.2	LfS
128	2	12-38	LS	84.2	8.6	7.2	LfS
129	4	44-66	SL	73.6	18.0	8.4	fS
130	5	66-120	LS	85.4	6.6	8.0	S
131	68-7-1	0-34	SL	69.6	22.2	8.2	fS
132	2	34-60	SL	52.6	29.4	18.0	CL
133	70-6-1	0-42	S	92.8	4.0	3.2	fS
134	2	42-60	S	90.0	7.0	3.0	fS
135	72-5-1	0-28	LS	79.0	12.8	8.2	fS
136	2	28-42	SL	71.4	12.4	16.2	SS
137	73-5-1	0-36	S	89.8	7.0	3.2	fS
138	2	36-66	LS	95.8	10.0	4.2	fS
139	3	66-104	SL	76.8	15.0	8.2	fSL
140	4	104-120	SL	77.6	10.4	12.0	L
141	75-4-1	0-24	SL	70.4	13.6	16.0	SL
142	2	24-46	SCL	56.0	22.0	22.0	L
143	3	46-60	L	39.8	14.2	46.0	C
144	76-4-1	0-12	SCL	52.0	25.8	22.2	L
145	76-4-2	12-48	SCL	52.2	24.4	23.4	CL
146	3	48-60	SL	69.0	13.0	18.0	SL
147	77-5-1	0-12	SL	70.4	19.6	10.0	SL
148	2	12-36	SL	70.4	13.6	16.0	L
149	3	36-60	LS	84.2	7.8	8.0	LfS
150	78-9-1	0-4	SL	70.0	16.0	14.0	SL
151	2	4-14	SCL	56.8	19.6	23.6	C
152	3	14-48	SL	69.2	18.2	12.6	LS
153	4	48-60	LS	82.8	7.6	9.6	LS
154	79-9-1	0-4	SL	58.6	32.8	8.6	SL
155	2	4-24	SCL	57.0	17.4	25.6	C
156	3	24-40	SCL	48.0	20.4	31.6	C
157	4	40-60	LS	81.8	8.6	9.6	LS
158	81-17-1	0-20	LL	38.4	29.0	32.6	C
159	2	20-60	L	17.0	37.2	45.8	C
160	82-17-1	0-12	SL	72.2	17.2	10.6	L
161	2	12-38	SL	77.4	13.0	9.6	SL
162	3	48-120	S	92.2	5.2	2.6	S
163	85-18-1	0-30	SL	80.2	9.2	10.6	S
164	87-7-1	0-24	LS	82.4	12.0	5.6	LfS
165	2	24-60	LSSL	79.6	10.8	9.6	LfS
166	17-25-1	0-12	S	93.4	5.0	1.6	fS
167	8-30-1	0-48	LS	80.0	17.4	2.6	LfS
168	2	48-82	S	90.4	4.8	4.8	S
169	3	94-120	SCL	47.8	26.6	25.6	SS
170	9-30-1	0-54	S	90.0	6.2	3.8	fS
171	2	54-108	S	88.2	7.2	4.6	S
172	10-30-1	0-36	SL	71.0	19.2	9.8	L
173	2	48-84	S	93.6	2.8	3.6	S
174	3	84-116	LS	87.0	5.2	7.8	S
175	13-24-1	0-12	SL	72.8	19.4	7.8	LfS
176	2	12-60	LS	91.6	12.6	5.8	fS
177	3	60-96	CL	33.6	28.8	37.6	SS & Sh
178	14-25-1	0-8	SL	59.6	29.8	10.6	fS
179	2	12-42	S	83.4	10.8	5.8	fS
180	3	42-64	S	94.4	3.0	2.6	S
181	15-25-1	0-12	LS	84.4	12.0	3.6	fS
182	2	12-36	SLS	88.2	6.2	5.6	fS
183	3	36-66	LS	79.4	13.0	7.6	LfS
184	4	66-94	L	49.8	30.6	19.6	CL
185	19-30-1	0-36	LS	82.2	13.2	4.6	fS
186	2	36-72	LS	86.0	9.4	4.6	fS
187	3	72-114	LS	81.8	12.4	5.8	LS
188	23-25-1	0-18	L	48.8	33.6	17.6	SL
189	2	18-46	SL	76.8	15.6	7.6	fS
190	3	46-90	S	90.6	3.8	5.6	S
191	4	90-114	SL	70.4	22.0	7.6	fS

Table Q-11(con.)
Mechanical Analysis of Soil Samples
Kimbeto Study Site, New Mexico

Lab Number	Profile Number	Depth in inches	Lab Texture	Particle Size Distribution			Field Texture
				Sand	Silt	Clay	
192	24-25-1	0-18	SL	76.4	16.0	7.6	fS
193	26-24-1	0-24	L	40.4	44.0	15.6	L
194	2	24-48	SL	72.4	21.0	6.6	SL
195	3	48-70	S	88.4	8.0	3.6	S
196	4	70-120	S	89.6	5.8	4.6	fS
197	27-24-1	0-22	SL	72.0	18.4	9.6	L
198	2	22-60	LS	88.2	6.0	5.8	fS
199	27-24-3	60-120	S	94.2	2.0	3.8	S
200	29-27-1	0-12	SL	68.0	20.4	11.6	L
201	2	12-36	SL	63.4	24.0	12.6	SL
202	3	36-82	SL	75.4	15.0	9.6	LfS
203	4	82-120	LS-SL	72.6	24.8	2.6	S
204	30-24-1	0-24	S-LS	86.2	12.0	1.8	fS
205	2	24-60	S	93.8	4.6	1.6	fS
206	33-13-1	0-8	L	44.2	40.2	15.6	L
207	2	8-34	L	50.0	32.4	17.6	L
208	3	34-48	L	39.2	45.2	15.6	L
209	4	48-96	L	34.6	41.8	23.6	CL
210	5	96-120	SL	56.4	28.0	15.6	fS
211	36-14-1	0-12	S	95.8	2.2	2.0	fS
212	2	12-54	S	89.6	7.4	3.0	fS
213	3	54-84	S	88.6	7.4	4.0	fS
214	4	84-120	S	91.8	5.2	3.0	S
215	37-14-1	0-12	LS	83.6	9.4	7.0	fS
216	2	12-32	SL	77.6	13.4	9.0	SL
217	37-14-3	32-48	SL	64.2	18.8	17.0	L
218	4	48-60	LS	83.4	9.4	7.2	fS
219	5	60-74	SL	54.2	9.6	36.2	Sh
220	6	80-120	C	20.0	23.0	57.0	Sh
221	39-15-1	0-12	LL	42.0	30.8	27.2	LfS
222	2	12-38	LS	81.8	14.0	4.2	fS
223	3	38-78	LS	83.6	9.2	5.2	fS
224	4	78-120	LS	80.4	15.6	4.0	fS
225	46-23-1	0-8	LS	85.0	7.8	7.2	fS
226	2	8-28	SL	76.0	14.8	9.2	SL
227	3	28-60	S	92.6	3.4	4.0	fS
228	4	60-120	S	96.0	.8	3.2	S
229	54-10-1	0-14	L	40.0	41.8	18.2	C
230	2	14-42	LL	20.4	46.4	33.2	C
231	3	42-66	SL	93.6	1.2	5.2	S
232	4	66-120	LS	85.6	9.2	5.2	fS
233	58-16-1	0-6	SL	67.0	18.8	14.2	CL
234	2	6-48	SL	70.6	22.2	7.2	LfS
235	58-16-3	48-84	SL	74.6	16.2	9.2	fS
236	4	84-120	SL	71.6	18.2	10.2	fSL
237	59-16-1	0-24	SL	69.4	21.4	9.2	fS
238	2	24-48	LS	83.6	9.2	5.2	fS
239	69-6-1	0-24	SL	75.4	13.4	11.2	SL
240	2	24-60	SL	65.4	15.6	19.0	L
241	3	60-120	LS	81.4	11.6	7.0	LfS
242	71-7-1	0-30	S	95.2	2.6	2.2	fS
243	2	30-60	SL	71.2	19.0	9.8	fSL
244	74-5-1	0-48	CL	37.8	28.4	33.8	SS & Sh
245	80-16-1	0-18	SL	66.0	20.0	14.0	L
246	2	18-36	SL	64.8	22.2	13.0	SL
247	3	48-60	S	89.6	3.2	7.2	S
248	4	60-96	S	91.2	4.8	4.0	fS
249	5	100-120	S	91.2	4.6	4.2	fS
250	84-18-1	0-20	SL	77.2	11.8	11.0	SL
251	2	20-40	LS	81.4	11.6	7.0	LfS
252	3	40-66	SL	72.0	16.8	11.2	SL

Table Q-11(con.)
Mechanical Analysis of Soil Samples
Kimbeto Study Site, New Mexico

Lab Number	Profile Number	Depth in inches **	Lab Texture	Particle Size Distribution			Field Texture
				Sand	Silt	Clay	
253	84-18-4	66-84	SL	73.2	11.6	15.2	SL
254	5	84-104	SL	68.4	26.3	5.2	SL
255	6	104-112	SiL	33.0	75.8	3.2	Ca
256	7	112-120	SCL	51.8	23.0	25.2	S
257	86-7-1	0-8	LS	83.2	9.6	7.2	C
258	88-17-1	0-20	LS	85.6	6.2	8.2	LfS
259	D.H.1-1	14.8-22.8	C	17.2	33.6	49.2	
260	2	33.8-40.8	C	23.8	31.2	45.0	
261	3	53.9-62.2	C	43.8	12.2	44.0	
262	4	67.7-81.9	SL	76.6	14.4	9.0	
263	5	85.1-94.5	SiL	26.8	51.7	21.5	
264	6	101.0-116.1	C	16.4	30.4	53.2	
265	7	129.8-147.8	SL	75.8	11.0	13.2	
266	8	147.8-157.8	SL	79.6	5.4	15.0	
267	9	161.0-180.5	SCL	55.2	11.8	33.0	
268	10	180.5-192.5	C	22.4	32.6	45.0	
269	11	199.6-221.0	SL	66.2	26.8	7.0	
270	12	221.0-236.5	SiC	15.2	41.8	43.0	

** D.H. depth in feet

Detailed Soil-Inventory Tables

SOIL SURVEY INTERPRETATIONS

KEYING ONLY — RECORD NO. — CONTROL WORD NO.

MLRA(S) 37 | KIND OF UNIT Series | UNIT NAME Blancot

STATE New Mexico | RECORD NO. | AUTHOR(S) TLP | DATE 2-76 | REVISED | UNIT MODIFIER

CLASSIFICATION AND BRIEF SOIL DESCRIPTION

CLASS 021 | DESCR 031

The Blancot series consists of deep well-drained soils. They formed in alluvium on upland valleys, side slopes, and alluvial fans. Elevations range from 5,600 to 6,400 feet. Mean annual precipitation is 6 to 10 inches. The mean annual air temperature is 50 to 55° F. Frost-free season is 140 to 160 days. Typically, the surface layer is pale brown loam about 2 inches thick. The subsoil is pale brown and light brownish-gray clay loam about 13 inches thick. The substratum is grayish brown and light brownish-gray sandy clay loam and clay loam to 60 inches. Slopes are 0 to 5 percent.

ESTIMATED SOIL PROPERTIES

PROP	FOOTNOTE	DEPTH (IN.)	USDA TEXTURE	UNIFIED	AASHO	FRACT. >3 IN. (PCT)	PERCENT OF MATERIAL LESS THAN 3 IN. PASSING SIEVE 4	10	40	200	LIQUID LIMIT	PLASTICITY INDEX
041		0-2	L, SIL, FSL	CL-ML	A-4	0	100	100	75-95	50-80	25-35	
042		0-2	SCL	SM-SC, CL-ML	A-4, A-6	0	100	100	80-90	35-55	20-40	
043		2-60	CL, SCL, L	CL-ML, CL	A-4, A-6	0	100	100	80-100	50-80	25-40	
044												
045												
046												

PROP	DEPTH (IN.)	PERMEABILITY (IN/HR)	AVAILABLE WATER CAPACITY (IN/IN)	SOIL REACTION (pH)	SALINITY (MMHOS/CM)	SHRINK-SWELL POTENTIAL	CORROSIVITY STEEL	CORROSIVITY CONCRETE	EROSION FACTORS K	EROSION FACTORS T	WIND EROD. GROUP
051		0.2-2.0	0.13 - 0.19	7.9 - 8.4	< 2	Low			.32	5	6
052	SAME DEPTH AS ABOVE	0.6-2.0	0.13 - 0.17	7.9 - 8.4	< 2	Low			.17	5	6
053		0.2-2.0	0.13 - 0.19	7.9 - 9.0	< 4	Moderate			.28		
054											
055											
056											

Clay (Pct of <2MM)
18-28
20-30
20-35

PROP	FLOODING FREQUENCY	FLOODING DURATION	FLOODING MONTHS	HIGH WATER TABLE DEPTH (FT)	HIGH WATER TABLE KIND	HIGH WATER TABLE MONTHS	CEMENTED PAN DEPTH (IN)	CEMENTED PAN HARDNESS	BEDROCK DEPTH (IN)	BEDROCK HARDNESS	SUBSIDENCE INITIAL (IN)	SUBSIDENCE TOTAL (IN)	HYD GRP	POTENTIAL FROST ACTION
061	None			> 6.0					> 60				B	

SANITARY FACILITIES

	FOOTNOTE	
SEPTIC 071	SEPTIC TANK ABSORPTION FIELDS	Slight
LAGOON 081	SEWAGE LAGOONS	0-2%: Moderate - Seepage 2+%: Moderate - Seepage, Slope
TRENCH 091	SANITARY LANDFILL (TRENCH)	Slight
SANARE 101	SANITARY LANDFILL (AREA)	Slight
COVER 111	DAILY COVER FOR LANDFILL	Good

BUILDING SITE DEVELOPMENT

	FOOTNOTE	
EXCAV 121	SHALLOW EXCAVATIONS	Slight
DWEL 131	DWELLINGS WITHOUT BASEMENTS	Moderate - Low Strength, Shrink-Swell
DWEL 141	DWELLINGS WITH BASEMENTS	Moderate - Low Strength, Shrink-Swell
BLDGS 151	SMALL COMMERCIAL BUILDINGS	0-4%: Moderate - Low Strength, Shrink-Swell 4+%: Moderate - Low Strength, Slope, Shrink-Swell
ROADS 161	LOCAL ROADS AND STREETS	Moderate - Shrink-Swell, Low Strength

REGIONAL INTERPRETATIONS

	FOOTNOTE	
REGION 171		
REGION 181		

SOURCE MATERIAL

KEYING ONLY	FOOTNOTE	
FILL 191	ROADFILL	Fair - Shrink-Swell
SAND 201	SAND	Unsuited
GRAVEL 211	GRAVEL	Unsuited
SOIL 221	TOPSOIL	Good

WATER MANAGEMENT

KEYING ONLY	FOOTNOTE	
PONDRS 231	POND RESERVOIR AREA	0-2%: Seepage 2+%: Seepage, Slope
DIKES 241	EMBANKMENTS DIKES AND LEVEES	Shrink-Swell, Low Strength
PONDAQ 251	EXCAVATED PONDS AQUIFER FED	No Water
DRAIN 261	DRAINAGE	Favorable
IRRIG 271	IRRIGATION	0-1%: Favorable 1+%: Slope
TERRAC 281	TERRACES AND DIVERSIONS	Favorable
WATERW 291	GRASSED WATERWAYS	

UNIT NAME: Blancot
UNIT MODIFIER:

RECREATIONAL DEVELOPMENT

KEYING ONLY RECORD NO.	KEYING ONLY CONTROL WORD	KEYING ONLY CONTROL NO.		FOOTNOTE
	CAMPS	301	CAMP AREAS	Slight
	PICNIC	311	PICNIC AREAS	Slight
	PLAYGO	321	PLAYGROUNDS	0-2%: Slight 2+%: Moderate - Slope
	PATHS	331	PATHS AND TRAILS	Slight

CAPABILITY AND PREDICTED YIELDS - CROPS AND PASTURE (HIGH LEVEL MANAGEMENT)

KEYING ONLY	CLASS-DETERMINING PHASE	CAPABILITY NIRR	CAPABILITY IRR.	NIRR	IRR.	NIRR	IRR.	NIRR	IRR.	NIRR	IRR.	NIRR	IRR.	NIRR	IRR.	NIRR	IRR.
CROPHD 451																	
CROPS 341	All	7C	---														
351																	

WOODLAND SUITABILITY

KEYING ONLY	CLASS-DETERMINING PHASE	ORD SYM	MANAGEMENT PROBLEMS: EROSION HAZARD	EQUIP. LIMIT	SEEDLING MORT'Y.	WINDTH. HAZARD	PLANT COMPET.	POTENTIAL PRODUCTIVITY: IMPORTANT TREES	SITE INDEX	TREES TO PLANT
WOODS 361										
371										

WIND BREAKS

KEYING ONLY	CLASS-DETERMINING PHASE	SPECIES	HT	SPECIES	HT	SPECIES	HT	SPECIES	HT
WINDBK 381		None							

WILDLIFE HABITAT SUITABILITY

KEYING ONLY	CLASS-DETERMINING PHASE	POTENTIAL FOR HABITAT ELEMENTS: GRAIN & SEED	GRASS & LEGUME	WILD HERB.	HARDWD TREES	CONIFER PLANTS	SHRUBS	WETLAND PLANTS	SHALLOW WATER	POTENTIAL AS HABITAT FOR: OPENLAND WILDLIFE	WOODLAND WILDLIFE	WETLAND WILDLIFE	RANGELAND WILDLIFE
WILDLF 391	All	V.Poor	V.Poor	Poor	---	---	Poor	Poor	V.Poor	V.Poor	---	V.Poor	Poor

POTENTIAL NATIVE PLANT COMMUNITY (RANGELAND OR FOREST UNDERSTORY VEGETATION)

KEYING ONLY	COMMON PLANT NAME	PLANT SYMBOL (NLSPN)	PERCENTAGE COMPOSITION (DRY WEIGHT) BY CLASS DETERMINING PHASE: All
PHASE 401			
PLANT 411	Western Wheatgrass	AGSM	20
2	Indian Ricegrass	ORHY	10
3	Four-wing Saltbush	ATCA2	10
4	Galleta	HIJA	15
5	Blue Grama	BOGR2	10
6	Big Sagebrush 1/	ARTR2	10
7	Bottlebrush Squirreltail	SIHY	5
8	Sand Dropseed	SPCR	5
9	Perennial Native Forbs	PPFF	10
421	Annual Native Forbs	AAFF	5
PRODUC 431	POTENTIAL PRODUCTION (LBS./AC. DRY WT): FAVORABLE YEARS		625
	NORMAL YEARS		450
	UNFAVORABLE YEARS		275

FOOTNOTES

NOTES 441 — SYM. 1: Not usually utilized by cattle. Utilized by sheep in the fall, winter, and spring.

Table Q-12(cont.)

NM0076 — SOIL SURVEY INTERPRETATIONS

MLRA(S): 37
HEB, 11-73
TYPIC HAPLARGIDS, FINE-LOAMY, MIXED, MESIC

DOAK SERIES

THE DOAK SERIES CONSISTS OF DEEP, WELL DRAINED SOILS. FORMED IN MIXED ALLUVIUM OR EOLIAN MATERIAL ON MESAS TOP. SLOPES 0 TO 5 PERCENT. ELEVATION RANGE 5400 TO 6200 FEET. MEAN ANNUAL PRECIPITATION IS 6 TO 10 INCHES. MEAN ANNUAL AIR TEMPERATURE IS 50 TO 54 F AND THE FROST FREE PERIOD IS 146 TO 160 DAYS. TYPICALLY THE SURFACE LAYER IS A BROWN CLAY LOAM ABOUT 5 INCHES THICK, THE SUBSOIL IS A CLAY LOAM ABOUT 38 INCHES THICK AND THE SUBSTRATUM IS A CALCAREOUS CLAY LOAM.

ESTIMATED SOIL PROPERTIES (A)

DEPTH (IN.)	USDA TEXTURE	UNIFIED	AASHO	FRACT >3 IN (PCT)	PERCENT OF MATERIAL LESS THAN 3" PASSING SIEVE NO. 4	10	40	200	LIQUID LIMIT	PLASTICITY INDEX
0-5	L	ML	A-4	0	100	100	80-95	60-75	<30	NP-5
0-5	FSL	SM, ML	A-4	0	100	100	80-95	40-60	<30	NP-5
0-5	CL	CL, CL-ML	A-6, A-4	0	100	100	90-100	65-80	25-40	5-20
5-60	CL, SICL, L	CL, CL-ML	A-6, A-4	0	100	100	80-100	60-80	25-40	5-20

DEPTH (IN.)	PERMEABILITY (IN/HR)	AVAILABLE WATER CAPACITY (IN/IN)	SOIL REACTION (PH)	SALINITY (MMHOS/CM)	SHRINK-SWELL POTENTIAL	CORROSIVITY STEEL	CONCRETE	EROSION FACTORS K	T	WIND EROD. GROUP
0-5	0.6-2.0	0.13-0.17	7.4-8.4	<2	LOW	MODERATE	LOW	.37	5	5
0-5	2.0-6.0	0.08-0.13	7.4-8.4	<2	LOW	MODERATE	LOW	.28	5	3
0-5	0.2-0.6	0.15-0.19	7.4-8.4	<2	MODERATE	MODERATE	LOW	.32	5	6
5-60	0.2-0.6	0.15-0.19	7.4-9.0	2-4	MODERATE	HIGH	LOW	.37		

FLOODING FREQUENCY	DURATION	MONTHS	HIGH WATER TABLE DEPTH (FT)	KIND	MONTHS	CEMENTED PAN DEPTH (IN)	HARDNESS	BEDROCK DEPTH (IN)	HARDNESS	SUBSIDENCE INIT. (IN)	TOTAL (IN)	HYD GRP	POTENT'L FROST ACTION
NONE			>6.0			-		>60		-		B	LOW

SANITARY FACILITIES

SEPTIC TANK ABSORPTION FIELDS	SEVERE-PERCS SLOWLY
SEWAGE LAGOON AREAS	0-2%: SLIGHT 2+%: MODERATE-SLOPE
SANITARY LANDFILL (TRENCH)	SLIGHT
SANITARY LANDFILL (AREA)	SLIGHT
DAILY COVER FOR LANDFILL	FAIR-TOO CLAYEY

COMMUNITY DEVELOPMENT

SHALLOW EXCAVATIONS	SLIGHT
DWELLINGS WITHOUT BASEMENTS	MODERATE-SHRINK-SWELL,LOW STRENGTH
DWELLINGS WITH BASEMENTS	MODERATE-SHRINK-SWELL,LOW STRENGTH
SMALL COMMERCIAL BUILDINGS	0-4%: MODERATE-SHRINK-SWELL,LOW STRENGTH 4+%: MODERATE-SHRINK-SWELL,LOW STRENGTH, SLOPE
LOCAL ROADS AND STREETS	SEVERE-LOW STRENGTH

REGIONAL INTERPRETATIONS

SOURCE MATERIAL

ROADFILL	POOR-LOW STRENGTH
SAND	UNSUITED
GRAVEL	UNSUITED
TOPSOIL	FAIR-TOO CLAYEY

WATER MANAGEMENT

POND RESERVOIR AREA	0-2%: FAVORABLE 2+%: SLOPE
EMBANKMENTS DIKES AND LEVEES	SHRINK-SWELL,LOW STRENGTH,COMPRESSIBLE
EXCAVATED PONDS AQUIFER FED	NO WATER
DRAINAGE	PERCS SLOWLY
IRRIGATION	0-1%: FAVORABLE 1+%: ERODES EASILY,SLOPE
TERRACES AND DIVERSIONS	ERODES EASILY
GRASSED WATERWAYS	ERODES EASILY

Table Q-12 (cont.)

RECREATION

CAMP AREAS	MODERATE-DUSTY	PLAYGROUNDS	0-2%: MODERATE-DUSTY 2-5%: MODERATE-SLOPE,DUSTY
PICNIC AREAS	MODERATE-DUSTY	PATHS AND TRAILS	MODERATE-DUSTY

CAPABILITY AND PREDICTED YIELDS -- CROPS AND PASTURE (HIGH LEVEL MANAGEMENT)

CLASS-DETERMINING PHASE	CAPABILITY															
	NIRR	IRR.	NIRR	IRR.	NIRR	IRR.	NIRR	IRR.	NIRR	IRR.	NIRR	IRR.	NIRR	IRR.	NIRR	IRR.
0-1%	7C	1														
1-3%	7E	2E														
3+%	7E	3E														

WOODLAND SUITABILITY

CLASS-DETERMINING PHASE	ORD SYM	MANAGEMENT PROBLEMS					POTENTIAL PRODUCTIVITY		TREES TO PLANT
		EROSION HAZARD	EQUIP. LIMIT	SEEDLING MORT'Y.	WINDTH. HAZARD	PLANT COMPET.	IMPORTANT TREES	SITE INDX	
							NONE		

WINDBREAKS

CLASS-DETERMIN'G PHASE	SPECIES	HT	SPECIES	HT	SPECIES	HT	SPECIES	HT
ALL,IRR	EASTERN REDCEDAR SIBERIAN ELM		ROCKY MT. JUNIPER WHITE MULBERRY		RUSSIAN-OLIVE SKUNKBUSH SUMAC		HONEYLOCUST	

WILDLIFE HABITAT SUITABILITY

CLASS-DETERMINING PHASE	POTENTIAL FOR HABITAT ELEMENTS									POTENTIAL AS HABITAT FOR:		
	GRAIN & SEED	GRASS & LEGUME	WILD HERB.	HARDWD TREES	CONIFER PLANTS	SHRUBS	WETLAND PLANTS	SHALLOW WATER	OPENLD WILDLF	WOODLD WILDLF	WETLAND WILDLF	RANGELD WILDLF
ALL,NIRR	V. POOR	V. POOR	POOR	-	-	POOR	POOR	V. POOR	V. POOR	-	V. POOR	POOR
0-3% IRR	GOOD	GOOD	GOOD	-	-	POOR	FAIR	FAIR	GOOD	-	FAIR	-
3+% IRR	FAIR	GOOD	GOOD	-	-	POOR	POOR	V. POOR	FAIR	-	V. POOR	-

POTENTIAL NATIVE PLANT COMMUNITY (RANGELAND OR FOREST UNDERST'RY VEGETATION)

COMMON PLANT NAME	PLANT SYMBOL (NLSPN)	PERCENTAGE COMPOSITION (DRY WEIGHT) BY CLASS DETERMINING PHASE: CL	L
BIG SAGEBRUSH 1/	ARTR2	5	5
BLUE GRAMA	BOGR2	20	25
FOURWING SALTBUSH	ATCA2	5	5
SIDEOATS GRAMA	BOCU	-	5
GALLETA	HIJA	15	10
INDIAN RICEGRASS	ORHY	5	10
NEEDLE-AND-THREAD	STCO4	5	10
WESTERN WHEATGRASS	AGSM	20	15
BOTTLEBRUSH SQUIRRELTAIL	SIHY	-	5
ALKALI SACATON	SPAI	20	-
SAND DROPSEED	SPCR	-	5
OTHER ANNUAL FORBS	AAFF	5	5
POTENTIAL PRODUCTION (LBS./AC. DRY WT):			
FAVORABLE YEARS		750	800
NORMAL YEARS		500	600
UNFAVORABLE YEARS		300	400

FOOTNOTES

A ESTIMATES BASED ON HIGHWAY TEST DATA OF 2 PEDON, AND CHARACTERIZATION DATA OF 2 PEDON FROM SAN JUAN COUNTY, N.M.

1 NOT USUALLY UTILIZED BY CATTLE. UTILIZED BY SHEEP IN THE SPRING AND FALL.

Table Q-12 (cont.)

NM0080 — SOIL SURVEY INTERPRETATIONS

MLRA(S): [illegible], 37 — FRUITLAND SERIES
MEB,TLP, 10-73
TYPIC TORRIORTHENTS, COARSE-LOAMY, MIXED (CALCAREOUS), MESIC

THE FRUITLAND SERIES CONSISTS OF DEEP, WELL DRAINED SOILS. FORMED IN MIXED ALLUVIUM ON PIEDMONT SLOPES, ALLUVIAL FANS, AND MESAS. SLOPES 0 TO 8 PERCENT. ELEVATION RANGE 4800 TO 6200 FEET. MEAN ANNUAL PRECIPITION IS 6 TO 10 INCHES. MEAN ANNUAL AIR TEMPERATURE IS 50 TO 54 F, AND THE FROST-FREE SEASON IS 140 TO 165 DAYS. TYPICALLY THE SURFACE LAYER IS A PALE BROWN CALCAREOUS SANDY LOAM ABOUT 10 INCHES THICK. THE UNDERLYING LAYERS ARE A PALE BROWN AND LIGHT YELLOWISH BROWN CALCAREOUS SANDY LOAM.

ESTIMATED SOIL PROPERTIES (A)

DEPTH (IN.)	USDA TEXTURE	UNIFIED	AASHO	FRACT >3 IN (PCT)	PERCENT OF MATERIAL LESS THAN 3" PASSING SIEVE NO. 4	10	40	200	LIQUID LIMIT	PLASTICITY INDEX
0-10	SL	SM	A-2, A-4	0	100	100	60-75	30-40	-	NP
0-10	SCL	SC, SM-SC, CL, CL-ML	A-6, A-4	0	100	100	80-90	35-55	25-35	5-15
10-60	FSL, SL	SM	A-4, A-2	0	100	100	60-85	30-50	-	NP

DEPTH (IN.)	PERMEABILITY (IN/HR)	AVAILABLE WATER CAPACITY (IN/IN)	SOIL REACTION (PH)	SALINITY (MMHOS/CM)	SHRINK-SWELL POTENTIAL	CORROSIVITY STEEL	CORROSIVITY CONCRETE	EROSION FACTORS K	EROSION FACTORS T	WIND EROD. GROUP
0-10	2.0-6.0	0.08-0.13	7.4-8.4	<4	LOW	HIGH	LOW	.24	5	3
0-10	0.6-2.0	0.13-0.17	7.4-8.4	<4	LOW	HIGH	LOW	.28	5	5
10-60	2.0-6.0	0.08-0.13	7.4-8.4	<4	LOW	HIGH	LOW	.28		

FLOODING FREQUENCY	FLOODING DURATION	FLOODING MONTHS	HIGH WATER TABLE DEPTH (FT)	HIGH WATER TABLE KIND	HIGH WATER TABLE MONTHS	CEMENTED PAN DEPTH (IN)	CEMENTED PAN HARDNESS	BEDROCK DEPTH (IN)	BEDROCK HARDNESS	SUBSIDENCE INIT. (IN)	SUBSIDENCE TOTAL (IN)	HYD GRP	POTENTIAL FROST ACTION
NONE			>6.0			-		>60		-		B	LOW

SANITARY FACILITIES

SEPTIC TANK ABSORPTION FIELDS	SLIGHT
SEWAGE LAGOON AREAS	SEVERE-SEEPAGE
SANITARY LANDFILL (TRENCH) [1]	SLIGHT
SANITARY LANDFILL (AREA) [1]	SLIGHT
DAILY COVER FOR LANDFILL	GOOD

COMMUNITY DEVELOPMENT

SHALLOW EXCAVATIONS	SLIGHT
DWELLINGS WITHOUT BASEMENTS	SLIGHT
DWELLINGS WITH BASEMENTS	SLIGHT
SMALL COMMERCIAL BUILDINGS	0-4%: SLIGHT 4+%: MODERATE-SLOPE
LOCAL ROADS AND STREETS	MODERATE-LOW STRENGTH

REGIONAL INTERPRETATIONS

SOURCE MATERIAL

ROADFILL	FAIR-LOW STRENGTH
SAND [2]	POOR-EXCESS FINES
GRAVEL [2]	POOR-EXCESS FINES
TOPSOIL	GOOD

WATER MANAGEMENT

POND RESERVOIR AREA	SEEPAGE
EMBANKMENTS DIKES AND LEVEES	PIPING, SEEPAGE, ERODES EASILY
EXCAVATED PONDS AQUIFER FED	NO WATER
DRAINAGE	FAVORABLE
IRRIGATION	DROUGHTY, SLOPE, ERODES EASILY
TERRACES AND DIVERSIONS	SLOPE, ERODES EASILY
GRASSED WATERWAYS	

FRUITLAND SERIES

Table Q-12 (cont.)

NM0080

RECREATION

CAMP AREAS	MODERATE-DUSTY	PLAYGROUNDS	0-2%: MODERATE-DUSTY 2-6%: MODERATE-SLOPE,DUSTY 6+%: SEVERE-SLOPE
PICNIC AREAS	MODERATE-DUSTY	PATHS AND TRAILS	MODERATE-DUSTY

CAPABILITY AND PREDICTED YIELDS -- CROPS AND PASTURE (HIGH LEVEL MANAGEMENT)

CLASS-DETERMINING PHASE	CAPABILITY		ALFALFA HAY (TONS)		PASTURE (AUM)		CORN (BU)		CORN SILAGE (TONS)		GRASS HAY (TONS)					
	NIRR	IRR.	NIRR	IRR.	NIRR	IRR.	NIRR	IRR.	NIRR	IRR.	NIRR	IRR.	NIRR	IRR.	NIRR	IRR.
0-2%	7E	2E		7		25		125		25		5				
2-5%	7E	3E		6		20		110		20		4.5				
5+%	7E	4E		5		18		-		-		4				

WOODLAND SUITABILITY

CLASS-DETERMINING PHASE	ORD SYM	MANAGEMENT PROBLEMS: EROSION HAZARD	EQUIP. LIMIT	SEEDLING MORT'Y.	WINDTH. HAZARD	PLANT COMPET.	POTENTIAL PRODUCTIVITY: IMPORTANT TREES	SITE INDX	TREES TO PLANT
							NONE		

WINDBREAKS

CLASS-DETERMIN'G PHASE	SPECIES	HT	SPECIES	HT	SPECIES	HT	SPECIES	HT
ALL,IRR	RUSSIAN-OLIVE	20	EASTERN REDCEDAR	20	ROCKY MT. JUNIPER	23		

WILDLIFE HABITAT SUITABILITY

CLASS-DETERMINING PHASE	POTENTIAL FOR HABITAT ELEMENTS: GRAIN & SEED	GRASS & LEGUME	WILD HERB.	HARDWD TREES	CONIFER PLANTS	SHRUBS	WETLAND PLANTS	SHALLOW WATER	POTENTIAL AS HABITAT FOR: OPENLD WILDLF	WOODLD WILDLF	WETLAND WILDLF	RANGELD WILDLF
NIRR	V. POOR	V. POOR	POOR	-	-	POOR	POOR	V. POOR	V. POOR	-	V. POOR	POOR
0-2% IRR	GOOD	GOOD	POOR	-	-	POOR	GOOD	POOR	FAIR	-	FAIR	FAIR
2-5% IRR	FAIR	GOOD	POOR	-	-	POOR	POOR	V. POOR	FAIR	-	V. POOR	POOR
5+% IRR	FAIR	GOOD	POOR	-	-	POOR	POOR	V. POOR	FAIR	-	V. POOR	POOR

POTENTIAL NATIVE PLANT COMMUNITY (RANGELAND OR FOREST UNDERSTORY VEGETATION)

COMMON PLANT NAME	PLANT SYMBOL (USDA)	PERCENTAGE COMPOSITION (DRY WEIGHT) BY CLASS DETERMINING PHASE: ALL
FOURWING SALTBUSH	ATCA2	10
BLUE GRAMA	BOGR2	20
GIANT DROPSEED	SPGI	10
INDIAN RICEGRASS	ORHY	25
GALLETA	HIJA	5
NEW MEXICO FEATHERGRASS	STNE2	5
MORMONTEA	EPNE	5
SAND DROPSEED	SPCR	5
WINTERFAT	EULA5	5
BIG SAGEBRUSH 3/	ARTR2	5
OTHER ANNUAL FORBS	AAFF	5
POTENTIAL PRODUCTION (LBS./AC. DRY WT): FAVORABLE YEARS		900
NORMAL YEARS		700
UNFAVORABLE YEARS		300

FOOTNOTES

2 STRATIFIED SAND, GRAVEL MAY OCCUR BELOW 40 INCHES.
A ESTIMATES OF ENGINEERING PROPERTIES ARE BASED ON TEST DATA OF 1 PEDON FROM SAN JUAN COUNTY, NEW MEXICO.
1 SEEPAGE OF LEACHATE IS NOT A LIMITATION.
3 NOT USUALLY UTILIZED BY CATTLE. UTILIZED BY SHEEP IN THE SPRING AND FALL.

Table Q-12 (cont.)

(1)

U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

SOIL SURVEY INTERPRETATIONS

MLRA(S) 37 | KIND OF UNIT Series | UNIT NAME Huerfano
STATE New Mexico | RECORD NO. | AUTHOR(S) TLP | DATE 2776 | REVISED | UNIT MODIFIER
CLASSIFICATION AND BRIEF SOIL DESCRIPTION

The Huerfano series consists of shallow, moderately well drained soils. They formed in alluvium of shale and sandstone, origin on mesas, upland valley bottoms and valley side slopes. Slopes are 1 to 8 percent. Elevations range from 5600 to 6400 feet. M.A.P. is 6 to 10 inches. The M.A.A.T. is 51 to 55°F. Frost-free season is 140 to 160 days. Typically, the surface layer is 2 inches of light, yellowish brown silty clay loam. The subsoil is light yellowish brown and light olive brown clay to 14 inches where shale, bedrock is encountered.

FOOTNOTE

ESTIMATED SOIL PROPERTIES

	DEPTH (IN.)	USDA TEXTURE	UNIFIED	AASHO	FRACT. >3 IN. (PCT.)	PERCENT OF MATERIAL LESS THAN 3 IN. PASSING SIEVE 4	10	40	200	LIQUID LIMIT	PLASTICITY INDEX
PROP	0-2	SICL, C	CL-ML, CH	A-7-6	0	100	100	90-100	75-95	40-65	15-35
	2-14	C	CL, CH	A-7-6	0	100	100	90-100	75-95	45-65	20-40
	14	WB									

	DEPTH (IN.)	PERMEABILITY (IN/HR)	AVAILABLE WATER CAPACITY (IN/IN)	SOIL REACTION (PH)	SALINITY (MMHOS/CM)	SHRINK-SWELL POTENTIAL	CORROSIVITY STEEL	CORROSIVITY CONCRETE	EROSION FACTORS K	EROSION FACTORS T	WIND EROD. GROUP
PROP	SAME DEPTH AS ABOVE	0.06-0.2	0.13 - 0.19	7.9-9.0	4 - >16	Moderate	High	Low	.24	1	4
		<0.06-0.2	0.10 - 0.17	7.9-9.6	4 - >16	Moderate	High	Low	.32		

	FLOODING FREQUENCY	FLOODING DURATION	FLOODING MONTHS	HIGH WATER TABLE DEPTH (FT)	HIGH WATER TABLE KIND	HIGH WATER TABLE MONTHS	CEMENTED PAN DEPTH (IN)	CEMENTED PAN HARDNESS	BEDROCK DEPTH (IN)	BEDROCK HARDNESS	SUBSIDENCE INITIAL (IN)	SUBSIDENCE TOTAL (IN)	HYD GRP	POTENTIAL FROST ACTION
PROP	None			> 6.0			--		10 - 20	Rippable	--		D	Low

SANITARY FACILITIES

FOOTNOTES

SEPTIC	SEPTIC TANK ABSORPTION FIELDS	A Severe - Perc slowly, depth to rock
LAGOON	SEWAGE LAGOONS	1 - 7%: Severe-depth to rock, 7 + %: Severe - depth to rock, slope
TRENCH	SANITARY LANDFILL (TRENCH)	Severe - depth to rock, too clayey
SANARE	SANITARY LANDFILL (AREA)	Slight
COVER	DAILY COVER FOR LANDFILL	Poor - Area reclaim, too clayey

COMMUNITY DEVELOPMENT

FOOTNOTES

EXCAV	SHALLOW EXCAVATIONS	A Severe - depth to rock, too clayey
DWEL	DWELLINGS WITHOUT BASEMENTS	Severe - Depth to rock, low strength
DWE	DWELLINGS WITH BASEMENTS	Severe - Depth to rock, low strength
SLDGS	SMALL COMMERCIAL BUILDINGS	Severe - Depth to rock, low strength
SOADS	LOCAL ROADS AND STREETS	Severe - Depth to rock, low strength

REGIONAL INTERPRETATIONS

FOOTNOTES

REGION	
REGION	

KEYING ONLY

SOURCE MATERIAL

FOOTNOTES

FILL	A Poor - Area reclaim, low strength
SAND	Unsuited
GRAVEL	Unsuited
SOIL	Poor - excess alkali, area reclaim, thin layer

WATER MANAGEMENT

FOOTNOTES

POND RES	A 1-2%: Depth to rock 2+%: Depth to rock, slope
DIKE	Depth to rock, compressible, low strength
POND AQ	No water
DRAIN	Depth to rock, excess alkali, perc slowly
IRRIG	Excess alkali, perc slowly, slope
TERRA	Depth to rock, perc slowly, slope
WATERWA	Not needed

FOOTNOTES | POND RESERVOIR AREA | EMBANKMENTS DIKES AND LEVEES | EXCAVATED PONDS AQUIFER FED | DRAINAGE | IRRIGATION | TERRACES AND DIVERSIONS | GRASSED WATERWAYS

Table Q-12 (cont.)

(2)

KEYING ONLY — RECORD NO. — CONTROL WORD NO.

UNIT NAME Huerfano
UNIT MODIFIER

RECREATION

KEYING ONLY		FOOTNOTE		FOOTNOTE
CAMPS 301	CAMP AREAS	B Moderate - perco slowly, too clayey	PLAYGD 321 PLAYGROUNDS	1-6%: Severe - depth to rock 6+%: Severe - depth to rock, slope
PICNIC 311	PICNIC AREAS	Severe - dusty, too clayey	PATHS 331 PATHS AND TRAILS	Moderate - too clayey, dusty

CAPABILITY AND PREDICTED YIELDS - CROPS AND PASTURE (HIGH LEVEL MANAGEMENT)

FOOTNOTE

CROPLD 351 / CROPS 341	CLASS-DETERMINING PHASE	CAPABILITY NIRR	CAPABILITY IRR.	NIRR	IRR.	NIRR	IRR.	NIRR	IRR.	NIRR	IRR.	NIRR	IRR.	NIRR	IRR.	NIRR	IRR.
	All	7S	--														

WOODLAND SUITABILITY

FOOTNOTE

WOODS 361	CLASS-DETERMINING PHASE	ORD SYM	MANAGEMENT PROBLEMS: EROSION HAZARD	EQUIP. LIMIT	SEEDLING MORT'Y.	WINDTH. HAZARD	PLANT COMPET.	POTENTIAL PRODUCTIVITY: IMPORTANT TREES	SITE INDEX	TREES TO PLANT
								None		

WIND BREAKS

FOOTNOTE

WINDBK 381	CLASS-DETERMINING PHASE	SPECIES	HT	SPECIES	HT	SPECIES	HT	SPECIES	HT
		None							

WILDLIFE HABITAT SUITABILITY

FOOTNOTE

WILDLF 391	CLASS-DETERMINING PHASE	POTENTIAL FOR HABITAT ELEMENTS: GRAIN & SEED	GRASS & LEGUME	WILD HERB.	HARDWD TREES	CONIFER PLANTS	SHRUBS	WETLAND PLANTS	SHALLOW WATER	POTENTIAL AS HABITAT FOR: OPENLAND WILDLIFE	WOODLAND WILDLIFE	WETLAND WILDLIFE	RANGELAND WILDLIFE
C	All	V.Poor	V.Poor	V.Poor	--	--	V.Poor	Poor	V.Poor	V.Poor	--	V.Poor	V.Poor

POTENTIAL NATIVE PLANT COMMUNITY (RANGELAND OR FOREST UNDERSTORY VEGETATION)

FOOTNOTE

PHASE 401 / PLANT 411	COMMON PLANT NAME	PLANT SYMBOL (NLSPN)	PERCENTAGE COMPOSITION (DRY WEIGHT) BY CLASS DETERMINING PHASE

PRODUC 431 — POTENTIAL PRODUCTION (LBS./AC. DRY WT)
FAVORABLE YEARS
NORMAL YEARS
UNFAVORABLE YEARS

NOTES 441

SYM.	FOOTNOTES
A	Ratings based on "Guide for Interpreting Engineering Uses of Soils," November 1971.
B	Recreation ratings based on soils memorandum 69, October 1968.
C	Wildlife ratings based on soils memorandum 74, January 1972.

SCS SOILS 5
REV. MAY 1972
FILE CODE SOILS 12

U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

SOIL SURVEY INTERPRETATIONS (Previously Tasaya)

KEYING ONLY: RECORD NO. | CONTROL: WORD (001), MLRA (011), STATE (011)

MLRA(S) 37 | KIND OF UNIT Series | UNIT NAME Muff
STATE New Mexico | RECORD NO. | AUTHOR(S) TLP | DATE 2-76 | REVISED | UNIT MODIFIER

CLASS (021) | DESCR (031)

CLASSIFICATION AND BRIEF SOIL DESCRIPTION
The Muff series consists of moderately deep, moderately well-drained soils. They formed in alluvium on mesas, upland valley bottoms, side slopes, and swales. Elevations range from 5,600 to 6,400 feet. Mean annual precipitation is 8 to 10 inches. The mean annual air temperature is 51° to 55° F. Frost-free season is 140 to 160 days. Typically, the surface layer is 4 inches of pale brown very fine sandy loam. The subsurface is an inch of light gray very fine sandy loam. The subsoil is 10 inches of brown and light brown clay loam. Shale bedrock is encountered at 24 inches. Slopes are 0 to 8 percent.

ESTIMATED SOIL PROPERTIES

PROP (041)	FOOTNOTE	DEPTH (IN.)	USDA TEXTURE	UNIFIED	AASHO	FRACT. >3 IN. (PCT)	PERCENT OF MATERIAL LESS THAN 3 IN. PASSING SIEVE: 4	10	40	200	LIQUID LIMIT	PLASTICITY INDEX
1		0-4	VFSL, L	CL-ML, CL	A-4, A-6	0	100	100	85-95	55-75	20-35	
2		4-24	CL, SCL	CL, SC	A-6	0	100	100	80-100	40-75	30-40	
3		24	WB									
4												
5												
6												

PROP (051)	DEPTH (IN.)	PERMEABILITY (IN/HR)	AVAILABLE WATER CAPACITY (IN/IN)	SOIL REACTION (pH)	SALINITY (MMHOS/CM)	SHRINK-SWELL POTENTIAL	CORROSIVITY: STEEL	CONCRETE	EROSION FACTORS: K	T	WIND EROD. GROUP	Clay (Pct of < 2MM)
1	0-4	0.6-2.0	0.10 - 0.13	7.9-9.0	2-4	Low			.28	2	3	15-27
2	4-24	0.06-0.6	0.10 - 0.14	8.5	4	Moderate			.37			28-35
3	SAME DEPTH AS ABOVE											
4												
5												
6												

PROP (061)	FLOODING: FREQUENCY	DURATION	MONTHS	HIGH WATER TABLE: DEPTH (FT)	KIND	MONTHS	CEMENTED PAN: DEPTH (IN)	HARDNESS	BEDROCK: DEPTH (IN)	HARDNESS	SUBSIDENCE: INITIAL (IN)	TOTAL (IN)	HYD GRP	POTENTIAL FROST ACTION
	None			>6.0			---		20-40	Rippable	---		C	Low

SANITARY FACILITIES

	FOOTNOTES	
SEPTIC (071)	SEPTIC TANK ABSORPTION FIELDS	Severe - Depth to rock, percs slowly
LAGOON (081)	SEWAGE LAGOONS	0-7%: Severe - Depth to rock 7+%: Severe - Depth to rock, slope
TRENCH (091)	SANITARY LANDFILL (TRENCH)	Severe - Depth to rock
SANARE (101)	SANITARY LANDFILL (AREA)	Slight
COVER (111)	DAILY COVER FOR LANDFILL	Poor - Area reclaim

BUILDING SITE DEVELOPMENT

	FOOTNOTES	
EXCAV (121)	SHALLOW EXCAVATIONS	Severe - Depth to rock
DWEL (131)	DWELLINGS WITHOUT BASEMENTS	Severe - Depth to rock
DWEL (141)	DWELLINGS WITH BASEMENTS	Severe - Depth to rock
BLDGS (151)	SMALL COMMERCIAL BUILDINGS	Severe - Depth to rock
ROADS (161)	LOCAL ROADS AND STREETS	Moderate - Depth to rock, low strength

REGIONAL INTERPRETATIONS

	FOOTNOTES	
REGION (171)		
REGION (181)		

SOURCE MATERIAL

KEYING ONLY		FOOTNOTES	
FILL (191)	ROADFILL		Poor - area reclaim, low strength
SAND (201)	SAND		Unsuited
GRAVEL (211)	GRAVEL		Unsuited
SOIL (221)	TOPSOIL		Poor - Excess sodium

WATER MANAGEMENT

	FOOTNOTES	
PONDRS (231)	POND RESERVOIR AREA	0-2%: Depth to rock 2+%: Depth to rock, slope
DIKES (241)	EMBANKMENTS DIKES AND LEVEES	Depth to rock, low strength
PONDAQ (251)	EXCAVATED PONDS AQUIFER FED	No water
DRAIN (261)	DRAINAGE	Depth to rock, excess sodium, percs slowly
IRRIG (271)	IRRIGATION	Excess sodium, percs slowly, slope
TERRAC (281)	TERRACES AND DIVERSIONS	Depth to rock, percs slowly, slope
WATERW (291)	GRASSED WATERWAYS	

Table Q-12 (cont.)

KEYING ONLY — RECORD NO. / CONTROL WORD / NO.

UNIT NAME Muff
UNIT MODIFIER

RECREATIONAL DEVELOPMENT

KEYING ONLY		FOOTNOTE
CAMPS 301	CAMP AREAS	Moderate - Percs slowly
PICNIC 311	PICNIC AREAS	Slight
PLAYGO 321	PLAYGROUNDS	0-2%: Moderate - Depth to rock, percs slowly 2-6%: Moderate - Depth to rock, percs slowly 6+%: Severe - Slope
PATHS 331	PATHS AND TRAILS	Slight

CAPABILITY AND PREDICTED YIELDS - CROPS AND PASTURE (HIGH LEVEL MANAGEMENT)

KEYING ONLY	FOOTNOTE	CLASS-DETERMINING PHASE	CAPABILITY NIRR	CAPABILITY IRR.	NIRR	IRR.	NIRR	IRR.	NIRR	IRR.	NIRR	IRR.	NIRR	IRR.	NIRR	IRR.	NIRR	IRR.
CROPHD 351																		
CROPS 341		All	7S	---														

WOODLAND SUITABILITY

KEYING ONLY	FOOTNOTE	CLASS-DETERMINING PHASE	ORD SYM	MANAGEMENT PROBLEMS: EROSION HAZARD	EQUIP. LIMIT	SEEDLING MORT'Y.	WINDTH. HAZARD	PLANT COMPET.	POTENTIAL PRODUCTIVITY: IMPORTANT TREES	SITE INDEX	TREES TO PLANT
WOODS 361											
371											

WIND BREAKS

KEYING ONLY	FOOTNOTE	CLASS-DETERMINING PHASE	SPECIES	HT	SPECIES	HT	SPECIES	HT	SPECIES	HT
WINDBK 381			None							

WILDLIFE HABITAT SUITABILITY

KEYING ONLY	FOOTNOTE	CLASS-DETERMINING PHASE	POTENTIAL FOR HABITAT ELEMENTS: GRAIN & SEED	GRASS & LEGUME	WILD HERB.	HARDWD TREES	CONIFER PLANTS	SHRUBS	WETLAND PLANTS	SHALLOW WATER	POTENTIAL AS HABITAT FOR: OPENLAND WILDLIFE	WOODLAND WILDLIFE	WETLAND WILDLIFE	RANGELAND WILDLIFE
WILDLF 391		All	V.Poor	V.Poor	V.Poor	---	---	V.Poor	Poor	V.Poor	V.Poor	---	V.Poor	V.Poor

POTENTIAL NATIVE PLANT COMMUNITY (RANGELAND OR FOREST UNDERSTORY VEGETATION)

KEYING ONLY	FOOTNOTE	COMMON PLANT NAME	PLANT SYMBOL (NLSPN)	PERCENTAGE COMPOSITION (DRY WEIGHT) BY CLASS DETERMINING PHASE
PHASE 401				
PLANT 411		Alkali Sacaton	SPAI	40
		Four-wing Saltbush	ATCA$_2$	15
		Galleta	HIJA^2	15
		Sand Dropseed	SPCR	5
		Threeawn	ARIST	5
		Shadescale	ATCO	10
		Black Greasewood 1/	SAVE$_4$	10
421				
PRODUC 431		POTENTIAL PRODUCTION (LBS./AC. DRY WT.): FAVORABLE YEARS		275
		NORMAL YEARS		150
		UNFAVORABLE YEARS		50

KEYING ONLY	SYM.	FOOTNOTES
NOTES 441	1	Utilized by cattle and sheep in winter and spring. Bloat and, perhaps, poisoning may result from eating this forage.

NM0364 SOIL INTERPRETATIONS RECORD

MLRA(S): 37
CWK, ADK, ~~3236~~ 9-77
TYPIC CALIORTHIDS COARSE-LOAMY, MIXED, MESIC

NAGEESI SERIES

THE NAGEESI SERIES CONSISTS OF DEEP WELL DRAINED SOILS. THEY FORMED IN ALLUVIAL AND AEOLIAN MATERIAL ON MESA TOPS AND UPLANDS. ELEVATIONS RANGE FROM 5600 TO 6400 FEET. M.A.P. IS 6 TO 10 INCHES. M.A.A.T. IS 51 TO 55 F. THE FROST FREE SEASON IS 140 TO 160 DAYS. TYPICALLY, THE SURFACE LAYER IS 4 INCHES OF BROWN SANDY LOAM. THE SUBSOIL IS 10 INCHES OF LIGHT BROWN STRONGLY CALCAREOUS SANDY LOAM. THE SUBSTRATUM IS 39 INCHES OF WHITE SANDY CLAY LOAM. BELOW 53 INCHES AND TO A DEPTH OF 60 OR MORE INCHES VERY PALE BROWN GRAVELLY SANDY LOAM IS PRESENT. SLOPES ARE 0 TO 8 PERCENT.

ESTIMATED SOIL PROPERTIES (A)

DEPTH (IN.)	USDA TEXTURE	UNIFIED	AASHTO	FRACT >3 IN (PCT)	PERCENT OF MATERIAL LESS THAN 3" PASSING SIEVE NO. 4	10	40	200	LIQUID LIMIT	PLASTICITY INDEX
0-14	SL, FSL, VFSL	CL-ML, CL, SM-SC, SC	A-4	0	100	100	65-90	35-60	20-30	NP-10
0-14	L, SIL, CL	ML, ~~CL-ML~~ CL	A-4, A-6	0	100	100	85-100	65-90	30-40	5-15
14-53	SCL, CL, L	CL, SC	A-6	0	100	100	80-100	40-75	25-40	10-20
53-72	GR-SL, SCL, CL	SM-SC, CL-ML, SC, CL	A-1, A-4, A-6, A-2	0	75-100	50-100	30-100	15-75	20-35	NP-15

DEPTH (IN.)	CLAY (PCT <2MM)	MOIST BULK DENSITY (G/CM3)	PERMEABILITY (IN/HR)	AVAILABLE WATER CAPACITY (IN/IN)	SOIL REACTION (PH)	SALINITY (MMHOS/CM)	SHRINK-SWELL POTENTIAL	EROSION FACTORS K	T	WIND EROD. GROUP	ORGANIC MATTER (PCT)	CORROSIVITY STEEL	CONCRETE
0-14	15-20	-	0.6-6.0	0.08-0.17	7.9-8.4	<2	LOW	.32	5	3	.4-.8	HIGH	LOW
0-14	25-35	-	0.2-2.0	0.13-0.19	7.9-8.4	<2	LOW	.37	5	4L	.4-.8		
14-53	18-35	-	0.2-0.6	0.13-0.19	7.9-8.4	<2	LOW	.43					
53-72	15-30	-	0.2-6.0	0.07-0.19	7.9-8.4	<2	LOW	.24					

FLOODING FREQUENCY	FLOODING DURATION	FLOODING MONTHS	HIGH WATER TABLE DEPTH (FT)	HIGH WATER TABLE KIND	HIGH WATER TABLE MONTHS	CEMENTED PAN DEPTH (IN)	CEMENTED PAN HARDNESS	BEDROCK DEPTH (IN)	BEDROCK HARDNESS	SUBSIDENCE INIT. (IN)	SUBSIDENCE TOTAL (IN)	HYD GRP	POTENTIAL FROST ACTION
NONE			>6.0			-		>60		-		C	LOW

SANITARY FACILITIES

SEPTIC TANK ABSORPTION FIELDS	SEVERE-PERCS SLOWLY
SEWAGE LAGOON AREAS	0-7%: ~~SEVERE~~-SEEPAGE ~~2-7%: MODERATE-SEEPAGE,SLOPE~~ 7+%: SEVERE-SLOPE, SEEPAGE
SANITARY LANDFILL (TRENCH)	SLIGHT
SANITARY LANDFILL (AREA)	SLIGHT
DAILY COVER FOR LANDFILL	FAIR-~~AREA RECLAIM~~ TOO CLAYEY

BUILDING SITE DEVELOPMENT

SHALLOW EXCAVATIONS	SLIGHT ~~MODERATE~~ - TOO CLAYEY
DWELLINGS WITHOUT BASEMENTS	MODERATE-LOW STRENGTH
DWELLINGS WITH BASEMENTS	MODERATE-LOW STRENGTH
SMALL COMMERCIAL BUILDINGS	0-4%: MODERATE-LOW STRENGTH 4+%: MODERATE-LOW STRENGTH,SLOPE
LOCAL ROADS AND STREETS	MODERATE-LOW STRENGTH
LAWNS, LANDSCAPING AND GOLF FAIRWAYS	

CONSTRUCTION MATERIAL

ROADFILL	FAIR-LOW STRENGTH
SAND	UNSUITED
GRAVEL	UNSUITED
TOPSOIL	FAIR-~~AREA RECLAIM, THIN LAYER, EXCESS LIME~~ TOO CLAYEY

WATER MANAGEMENT

POND RESERVOIR AREA	SLOPE,SEEPAGE
EMBANKMENTS DIKES AND LEVEES	~~LOW STRENGTH~~ FAVORABLE
EXCAVATED PONDS AQUIFER FED	NO WATER
DRAINAGE	0-3%: FAVORABLE 3+%: SLOPE
IRRIGATION	~~EXCESS LIME, ROOTING DEPTH,~~ SLOPE SOIL BLOWING.
TERRACES AND DIVERSIONS	ERODES EASILY,SOIL BLOWING
GRASSED WATERWAYS	

REGIONAL INTERPRETATIONS

NAGEESI SERIES

NAGEESI

Table 12 (cont.)

NM0364

RECREATIONAL DEVELOPMENT

CAMP AREAS	~~MODERATE-DUSTY~~ SL,FSL,VFSL, L,SiL: MODERATE - PERCS SLOWLY CL: MODERATE - PERCS SLOWLY, TOO CLAYEY	PLAYGROUNDS	0-2%: MODERATE-~~SLIGHT~~ PERCS SLOWLY 2-6%: MODERATE-SLOPE, ~~DUSTY~~ PERCS SLOWLY 6+%: SEVERE-SLOPE
PICNIC AREAS	~~MODERATE-DUSTY~~ SL,FSL,VFSL,L,SiL: SLIGHT CL: MODERATE - TOO CLAYEY	PATHS AND TRAILS	~~MODERATE-DUSTY~~ SL,FSL,VFSL,L,SiL: SLIGHT CL: MODERATE - TOO CLAYEY

CAPABILITY AND YIELDS PER ACRE OF CROPS AND PASTURE (HIGH LEVEL MANAGEMENT)

CLASS-DETERMINING PHASE	CAPABILITY		ALFALFA HAY (TONS)		CORN SILAGE (TONS)		CORN (BU)		PASTURE (AUM)		APPLES (BU)		GRASS HAY (TONS)			
	NIRR	IRR.	NIRR	IRR.	NIRR	IRR.	NIRR	IRR.	NIRR	IRR.	NIRR	IRR.	NIRR	IRR.	NIRR	IRR.
0-3%	7E	3E	-	5	-	15	-	100	-	10	-		-	3.5		
3-5%	7E	4E	-	4.5	-	15	-	90	-	10	-		-	3.5		
5-8%	7E	6E	-	4.0	-	-	-	-	-	8	-		-	3.0		

WOODLAND SUITABILITY

CLASS-DETERMINING PHASE	ORD SYM	MANAGEMENT PROBLEMS: EROSION HAZARD	EQUIP. LIMIT	SEEDLING MORTY.	WINDTH. HAZARD	PLANT COMPET.	POTENTIAL PRODUCTIVITY: COMMON TREES	SITE INDX	TREES TO PLANT
							NONE		

WINDBREAKS

CLASS-DETERMING PHASE	SPECIES	HT	SPECIES	HT	SPECIES	HT	SPECIES	HT
HR	ORIENTAL ARBORVITAE	10	SIBERIAN ELM	45	RUSSIAN-OLIVE	20	BLUE SPRUCE	30
	MULTIFLORA ROSE	4	LOMBARDY POPLAR	50	ROCKY MT. JUNIPER	23	AUSTRIAN PINE	35

WILDLIFE HABITAT SUITABILITY

CLASS-DETERMINING PHASE	POTENTIAL FOR HABITAT ELEMENTS: GRAIN & SEED	GRASS & LEGUME	WILD HERB.	HARDWD TREES	CONIFER PLANTS	SHRUBS	WETLAND PLANTS	SHALLOW WATER	POTENTIAL AS HABITAT FOR: OPENLD WILDLF	WOODLD WILDLF	WETLAND WILDLF	RANGELD WILDLF
NIRR	V. POOR	V. POOR	POOR	-	-	POOR	POOR	V. POOR	V. POOR	-	V. POOR	POOR
0-3% IRR	FAIR	FAIR	GOOD	-	-	FAIR	POOR	FAIR	FAIR	-	POOR	-
3-5% IRR	FAIR	FAIR	GOOD	-	-	FAIR	POOR	V. POOR	FAIR	-	V. POOR	-
5-8% IRR	POOR	FAIR	GOOD	-	-	FAIR	POOR	V. POOR	FAIR	-	V. POOR	-

POTENTIAL NATIVE PLANT COMMUNITY (RANGELAND OR FOREST UNDERSTORY VEGETATION)

COMMON PLANT NAME	PLANT SYMBOL (NLSPN)	PERCENTAGE COMPOSITION (DRY WEIGHT) BY CLASS DETERMINING PHASE: ALL
INDIAN RICEGRASS	ORHY	35
WINTERFAT	EULA5	10
GALLETA	HIJA	15
BLUE GRAMA	BOGR2	10
BROOM SNAKEWEED 1/	GUSA2	5
MORMONTEA	EPHED	15
OTHER PERENNIAL FORBS	PPFF	5
THREEAWN	ARIST	5
POTENTIAL PRODUCTION (LBS./AC. DRY WT):		
FAVORABLE YEARS		450
NORMAL YEARS		300
UNFAVORABLE YEARS		100

FOOTNOTES

NOT USUALLY UTILIZED BY CATTLE OR SHEEP.
ESTIMATES OF ENGINEERING PROPERTIES ARE BASED ON TEST DATA OF 2 PEDONS FROM SAN JUAN COUNTY, NM.

SCS-SOILS-5
REV. MAY 1972
FILE CODE: SOILS 12

U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

SOIL SURVEY INTERPRETATIONS

KEYING ONLY: RECORD NO. | CONTROL WORD | NO.
MLRA | 003
STATE | 011

MLRA(S) 37 | KIND OF UNIT: Series | UNIT NAME: Notal
STATE: New Mexico | RECORD NO | AUTHOR(S): ADK, JEP | DATE: 2-76 | REVISED | UNIT MODIFIER

CLASS 021
DESCR 031

CLASSIFICATION AND BRIEF SOIL DESCRIPTION

The Notal series consists of deep moderately well drained soils. They formed on upland valley bottoms and drainageways from alluvium of shale and sandstone origin. Elevations range from 5,600 to 6,400 feet. Mean annual precipitation ranges from 6 to 10 inches. Mean annual air temperatures range from 51° to 55° F, and the frost-free season is 140 to 160 days. Typically, the surface layer is a grayish brown silty clay loam about 3 inches thick. The subsoil is a grayish brown about 20 inches thick. The substratum is a grayish brown clay to 60 inches or more. Slopes are from 0 to 2 percent.

ESTIMATED SOIL PROPERTIES

	FOOTNOTE	DEPTH (IN.)	USDA TEXTURE	UNIFIED	AASHO	FRACT. >3 IN. (PCT)	PERCENT OF MATERIAL LESS THAN 3 IN. PASSING SIEVE: 4	10	40	200	LIQUID LIMIT	PLASTICITY INDEX
PROP 041	1	0 - 3	SICL, CL	CL	A-6, A-7	0	100	100	90-100	70-80	35-45	
2	1	0 - 3	SIC, C	CL, CH	A-7	0	100	100	90-100	80-95	40-65	
3		3 - 60	SIC, C	CL, CH	A-7	0	100	100	90-100	80-95	40-65	
4												
5												
6												

	DEPTH (IN.)	PERMEABILITY (IN/HR)	AVAILABLE WATER CAPACITY (IN/IN)	SOIL REACTION (PH)	SALINITY (MMHOS/CM)	SHRINK-SWELL POTENTIAL	CORROSIVITY: STEEL	CONCRETE	EROSION FACTORS: K	T	WIND EROD. GROUP
PROP 051		0.2-0.6	0.11 - 0.14	7.9-9.0	4 - 8	Moderate	High	High	.32	5	4L
2	SAME DEPTH AS ABOVE	< 0.2	0.10 - 0.14	7.9-9.0	4 - 8	High			.37	5	4L
3		< 0.06	0.10 - 0.14	7.9-9.0	4 - 8	High			.43		
4											
5											
6											

Clay (Pct of < 2MM)
28-35
40-60
40-60

	FLOODING: FREQUENCY	DURATION	MONTHS	HIGH WATER TABLE: DEPTH (FT)	KIND	MONTHS	CEMENTED PAN: DEPTH (IN)	HARDNESS	BEDROCK: DEPTH (IN)	HARDNESS	SUBSIDENCE: INITIAL (IN)	TOTAL (IN)	HYD GRP	POTENTIAL FROST ACTION
PROP 061	None			>6.0			---		>60		---		D	Low

SANITARY FACILITIES

	FOOTNOTES	
SEPTIC 071	SEPTIC TANK ABSORPTION FIELDS	Severe: Percs slowly
LAGOON 081	SEWAGE LAGOONS	Slight
TRENCH 091	SANITARY LANDFILL (TRENCH)	Severe - Too clayey
SANARE 101	SANITARY LANDFILL (AREA)	Slight
COVER 111	DAILY COVER FOR LANDFILL	Poor - Too clayey

BUILDING SITE DEVELOPMENT

	FOOTNOTES	
EXCAV 121	SHALLOW EXCAVATIONS	Severe - Too clayey
DWEL 131	DWELLINGS WITHOUT BASEMENTS	Severe - Shrink-swell, low strength
DWEL 141	DWELLINGS WITH BASEMENTS	Severe - Shrink-swell, low strength
BLDGS 151	SMALL COMMERCIAL BUILDINGS	Severe - Shrink-swell, low strength
ROADS 161	LOCAL ROADS AND STREETS	Severe - Shrink-swell, low strength

REGIONAL INTERPRETATIONS

	FOOTNOTES	
REGION 171		
REGION 181		

SOURCE MATERIAL

KEYING ONLY	FOOTNOTES	
FILL 191	ROADFILL	Poor - Shrink-swell, low strength
SAND 201	SAND	Unsuited
GRAVEL 211	GRAVEL	Unsuited
SOIL 221	TOPSOIL	Poor - Excess sodium, too clayey

WATER MANAGEMENT

	FOOTNOTES	
PONDRS 231	POND RESERVOIR AREA	Favorable
DIKES 241	EMBANKMENTS DIKES AND LEVEES	Shrink-Swell, Low strength, piping
PONDAQ 251	EXCAVATED PONDS AQUIFER FED	No water
DRAIN 261	DRAINAGE	Excess sodium, percs slowly
IRRIG 271	IRRIGATION	Percs slowly, excess sodium
TERRAC 281	TERRACES AND DIVERSIONS	Percs slowly, too clayey, piping
WATERW 291	GRASSED WATERWAYS	

Table Q-12 (cont.)

(2)

KEYING ONLY: RECORD NO. | CONTROL WORD | NO.

UNIT NAME Notal
UNIT MODIFIER

RECREATIONAL DEVELOPMENT

KEYING ONLY		FOOTNOTE	KEYING ONLY		FOOTNOTE
CAMPS 301	CAMP AREAS	Severe - perco slowly	PLAYGD 321	PLAYGROUNDS	Severe - perco slowly
PICNIC 311	PICNIC AREAS	Moderate - too clayey	PATHS 331	PATHS AND TRAILS	Moderate - too clayey

CAPABILITY AND PREDICTED YIELDS - CROPS AND PASTURE (HIGH LEVEL MANAGEMENT)

GROPHD 351 | CROPS 341

FOOTNOTE	CLASS-DETERMINING PHASE	CAPABILITY NIRR	CAPABILITY IRR.	NIRR	IRR.	NIRR	IRR.	NIRR	IRR.	NIRR	IRR.	NIRR	IRR.	NIRR	IRR.	NIRR	IRR.	NIRR	IRR.
	All	7S	---																

WOODLAND SUITABILITY

WOODS 361

FOOTNOTE	CLASS-DETERMINING PHASE	ORD SYM	MANAGEMENT PROBLEMS: EROSION HAZARD	EQUIP. LMIT	SEEDLING MORT'Y.	WINDTH. HAZARD	PLANT COMPET.	POTENTIAL PRODUCTIVITY: IMPORTANT TREES	SITE INDEX	TREES TO PLANT

WIND BREAKS

WINDBK 381

FOOTNOTE	CLASS-DETERMINING PHASE	SPECIES	HT	SPECIES	HT	SPECIES	HT	SPECIES	HT

WILDLIFE HABITAT SUITABILITY

WILDLF 391

FOOTNOTE	CLASS-DETERMINING PHASE	POTENTIAL FOR HABITAT ELEMENTS: GRAIN & SEED	GRASS & LEGUME	WILD HERB.	HARDWD TREES	CONIFER PLANTS	SHRUBS	WETLAND PLANTS	SHALLOW WATER	POTENTIAL AS HABITAT FOR: OPENLAND WILDLIFE	WOODLAND WILDLIFE	WETLAND WILDLIFE	RANGELAND WILDLIFE
	All	V.Poor	V.Poor	V.Poor	---	---	Poor	Poor	Poor	V.Poor	---	Poor	V.Poor

POTENTIAL NATIVE PLANT COMMUNITY (RANGELAND OR FOREST UNDERSTORY VEGETATION)

PHASE 401 | PLANT 411

FOOTNOTE	COMMON PLANT NAME	PLANT SYMBOL (NLSPM)	PERCENTAGE COMPOSITION (DRY WEIGHT) BY CLASS DETERMINING PHASE: Run-in	Dissected
	Alkali sacaton	SPAI	15	30
	Western wheatgrass	AGSM	30	5
	Galleta	HIJA	15	15
	Black greasewood 1/	SAVE4	10	10
	Big sagebrush 2/	$ARTR_2$	5	-
	Shadscale	ARCO	10	10
	Perennial native forbs	PPFF	10	5
	Four-wing saltbush	$ATCA_2$	-	15
	Sand dropseed	SPCR	-	5
	Threeawn	ARIST	-	5

PRODUC 431

POTENTIAL PRODUCTION (LBS./AC. DRY WT):	Run-in	Dissected
FAVORABLE YEARS	1,250	
NORMAL YEARS	850	
UNFAVORABLE YEARS	375	

FOOTNOTES

NOTES 341

SYM.	
1	Utilized by cattle and sheep in winter and spring. Bloat and, perhaps, poisoning may result from eating this forage.
2	Not usually utilized by cattle. Utilized in the fall, winter, and spring.

Table Q-17 (cont.)

SOIL SURVEY INTERPRETATIONS

MLRA(S) 17 | KIND OF UNIT Series | UNIT NAME Persayo

STATE Colorado | RECORD NO | AUTHOR(S) CUK | DATE 3-77 | REVISED | UNIT MODIFIER

CLASSIFICATION AND BRIEF SOIL DESCRIPTION

The Persayo series consists of shallow well-drained, moderately fine-textured soils. Formed in weathered shales. They occupy upland hills, ridges, and breaks. Elevations range from 5,200 to 6,400 feet. Mean annual precipitation ranges from 8 to 10 inches. Mean annual air temperature is about 530 F. Frost-free season ranges from 140 to 160 days. A typical pedon is light brownish-gray clay loam to 8 inches. The underlying layer is light brownish-gray silty clay loam underlain by shale at 20 inches. Slopes range from 1 to 40 percent.

ESTIMATED SOIL PROPERTIES

	DEPTH (IN.)	USDA TEXTURE	UNIFIED	AASHO	FRACT. >3 IN. (PCT)	PERCENT OF MATERIAL LESS THAN 3 IN. PASSING SIEVE 4	10	40	200	LIQUID LIMIT	PLASTICITY INDEX
PROP	0-20	CL, SICL	CL	A-6, A-7	0	100	100	90-100	70-95	30-50	
	20	WR									

	DEPTH (IN.)	PERMEABILITY (IN/HR)	AVAILABLE WATER CAPACITY (IN/IN)	SOIL REACTION (PH)	SALINITY (MMHOS/CM)	SHRINK-SWELL POTENTIAL	CORROSIVITY STEEL	CORROSIVITY CONCRETE	EROSION FACTORS K	EROSION FACTORS T	WIND EROD. GROUP	Clay (Pct of < 2MM)
PROP	SAME DEPTH AS ABOVE	0.2-0.6	0.15 - 0.19	7.9-9.0	2 - 4	Moderate	High	Low	.37	1	4L	28-35

	FLOODING FREQUENCY	FLOODING DURATION	FLOODING MONTHS	HIGH WATER TABLE DEPTH (FT)	HIGH WATER TABLE KIND	HIGH WATER TABLE MONTHS	CEMENTED PAN DEPTH (IN)	CEMENTED PAN HARDNESS	BEDROCK DEPTH (IN)	BEDROCK HARDNESS	SUBSIDENCE INITIAL (IN)	SUBSIDENCE TOTAL (IN)	HYD GRP	POTENTIAL FROST ACTION
PROP	None			>6.0			--		10-20	Rippable	--		D	Low

SANITARY FACILITIES

	FOOTNOTES	
SEPTIC	SEPTIC TANK ABSORPTION FIELDS	0-15%: Severe - Depth to rock 15+%: Severe - Depth to rock, slope
LAGOON	SEWAGE LAGOONS	0-7%: Severe - Depth to rock 7+%: Severe - Depth to rock, slope
TRENCH	SANITARY LANDFILL (TRENCH)	0-25%: Severe - Depth to rock 25+%: Severe - Depth to rock, slope
SANARE	SANITARY LANDFILL (AREA)	0-8%: Slight 8-15%: Moderate - Slope 15+%: Severe - Slope
COVER	DAILY COVER FOR LANDFILL	0-15%: Poor - Thin layer, area reclaim 15+%: Poor - Thin layer, area reclaim, slope

BUILDING SITE DEVELOPMENT

	FOOTNOTES	
EXCAV	SHALLOW EXCAVATIONS	0-8%: Moderate - Depth to rock 8-15%: Moderate - Depth to rock, slope 15+%: Severe - Slope
DWEL	DWELLINGS WITHOUT BASEMENTS	0-8%: Moderate - Shrink-swell, depth to rock 8-15%: Moderate - Shrink-swell, depth to rock, slope 15+%: Severe - Slope
DWEL	DWELLINGS WITH BASEMENTS	0-8%: Moderate - Shrink-swell, depth to rock 8-15%: Moderate - Shrink-swell, depth to rock, slope 15+%: Severe - Slope
BLDGS	SMALL COMMERCIAL BUILDINGS	0-4%: Moderate - Shrink-swell, depth to rock 4-8%: Moderate - Shrink-swell, depth to rock 8+%: Severe - Slope
ROADS	LOCAL ROADS AND STREETS	0-8%: Moderate - Shrink-swell, depth to rock 8-15%: Moderate - Shrink-swell, depth to rock, slope 15+%: Severe - Slope

REGIONAL INTERPRETATIONS

	FOOTNOTES	
REGION		
REGION		

SOURCE MATERIAL

KEYING ONLY	FOOTNOTES	
FILL	ROADFILL	0-25%: Poor - Thin layer, area reclaim 25+%: Poor - Thin layer, area reclaim
SAND	SAND	Unsuited
GRAVEL	GRAVEL	Unsuited
SOIL	TOPSOIL	0-15%: Poor - Area reclaim 15+%: Poor - Area reclaim, slope

WATER MANAGEMENT

KEYING ONLY	FOOTNOTES	
POWRS	POND RESERVOIR AREA	Slope, depth to rock
DIKES	EMBANKMENTS DIKES AND LEVEES	Thin layer, shrink-swell, compressable
PONDAQ	EXCAVATED PONDS AQUIFER FED	No water
DRAIN	DRAINAGE	
IRRIG	IRRIGATION	
TERRAC	TERRACES AND DIVERSIONS	0-5%: Depth to rock, erodes easily 5+%: Complex slope, depth to rock, erodes easily
WATERW	GRASSED WATERWAYS	

Table Q-12 (cont.)

(2)

UNIT NAME Persayo

UNIT MODIFIER

RECREATIONAL DEVELOPMENT

KEYING ONLY RECORD NO.	CONTROL CARD	NO.		FOOTNOTE
	CAMPS	321	CAMP AREAS	0-8%: Moderate - Percs slowly, too clayey 8-15%: Moderate - Percs slowly, too clayey, slope 15+%: Severe - Slope
	PICNIC	331	PICNIC AREAS	0-8%: Moderate - Too clayey 8-15%: Moderate - Too clayey, slope 15+%: Severe - Slope

KEYING ONLY				FOOTNOTE
	PLAYGD	321	PLAYGROUNDS	0-6%: Moderate - Percs slowly, too clayey, slope 6+%: Severe - Slope
	PATHS	331	PATHS AND TRAILS	0-15%: Moderate - Too clayey 15-25%: Moderate - Too clayey, slope 25+%: Severe - Slope

CAPABILITY AND PREDICTED YIELDS - CROPS AND PASTURE (HIGH LEVEL MANAGEMENT)

	CLASS DETERMINING PHASE	CAPABILITY															
		NIRR	IRR.	NIRR	IRR.	NIRR	IRR.	NIRR	IRR.	NIRR	IRR.	NIRR	IRR.	NIRR	IRR.	NIRR	IRR.
CROPS 341	All	7E															

WOODLAND SUITABILITY

	CLASS DETERMINING PHASE	ORD SYM	MANAGEMENT PROBLEMS: EROSION HAZARD	EQUIP LIMIT	SEEDLING MORTY.	WINDTH. HAZARD	PLANT COMPET.	POTENTIAL PRODUCTIVITY: IMPORTANT TREES	SITE INDEX	TREES TO PLANT
WOODS 361	All	4d	Severe	Slight	Severe	Moderate	Slight	Oneseed Juniper Pinyon	60	-

WINDBREAKS

	CLASS DETERMINING PHASE	SPECIES	HT	SPECIES	HT	SPECIES	HT	SPECIES	HT
WINDBK 361		None							

WILDLIFE HABITAT SUITABILITY

	CLASS DETERMINING PHASE	POTENTIAL HABITAT ELEMENTS: GRASS & LEGUME	GRASS & LEGUME	WILD HERB.	HARDWD TREES	CONIFER PLANTS	SHRUBS	WETLAND PLANTS	SHALLOW WATER	POTENTIAL AS HABITAT FOR: OPENLAND WILDLIFE	WOODLAND WILDLIFE	WETLAND WILDLIFE	RANGELAND WILDLIFE
WILDLF 371	All	V.Poor	V.Poor	Poor	--	--	Poor	V.Poor	V.Poor	V.Poor	--	V.Poor	V.Poor

POTENTIAL NATIVE PLANT COMMUNITY (RANGELAND OR FOREST UNDERSTORY VEGETATION)

	COMMON PLANT NAME	PLANT SYMBOL (NRCS#)	PERCENTAGE COMPOSITION BY CLASS DETERMINING PHASE				
PHASE							
PLANT 411							
PRODUC 431	POTENTIAL PRODUCTION (LBS./AC. DRY WT.) FAVORABLE YEARS NORMAL YEARS UNFAVORABLE YEARS						

SYM. FOOTNOTES

NOTES 441

Table Q-12 (cont.)

UT0229 SOIL SURVEY INTERPRETATIONS

SOIL SERIES FILE

SHEPPARD SERIES

MLRA(S): 34, 35
MEO, 4-75
TYPIC TORRIFLUVENTS, MIXED, MESIC

THE SHEPPARD SERIES ARE VERY DEEP, SOMEWHAT EXCESSIVELY-DRAINED SOILS FORMED IN SANDY MATERIAL ON ROLLING UPLANDS UNDER GALLETA, SAND DROPSEED, AND SALTBUSH. MAST IS 54 TO 59 F. AAP IS 6 TO 8 INCHES. FFP IS 130 TO 150 DAYS. A TYPICAL PROFILE HAS A REDDISH-YELLOW FINE SAND SURFACE LAYER, 12 INCHES THICK. THE UNDERLYING LAYER IS REDDISH-YELLOW LOAMY FINE SAND TO 60 INCHES OR MORE. SLOPES ARE 3 TO 12 PERCENT.

ESTIMATED SOIL PROPERTIES (A)

DEPTH (IN.)	USDA TEXTURE	UNIFIED	AASHTO	FRACT >3 IN (PCT)	PERCENT OF MATERIAL LESS THAN 3" PASSING SIEVE NO. 4	10	40	200	LIQUID LIMIT	PLASTICITY INDEX
0-12	FS	SM	A-2	0	100	100	65-80	10-20	-	NP
12-60	LFS	SM	A-2	0	100	100	70-80	15-25	-	NP

DEPTH (IN.)	PERMEABILITY (IN/HR)	AVAILABLE WATER CAPACITY (IN/IN)	SOIL REACTION (PH)	SALINITY (MMHOS/CM)	SHRINK-SWELL POTENTIAL	CORROSIVITY STEEL	CORROSIVITY CONCRETE	EROSION FACTORS K	EROSION FACTORS T	WIND ERODI. GROUP
0-12	6.0-20	0.05-0.07	7.9-9.0	<2	LOW	HIGH	MODERATE	.10	5	1
12-60	6.0-20	0.06-0.08	7.9-9.0	<2	LOW	HIGH	MODERATE	.10		

FLOODING FREQUENCY	FLOODING DURATION	FLOODING MONTHS	HIGH WATER TABLE DEPTH (FT)	HIGH WATER TABLE KIND	HIGH WATER TABLE MONTHS	CEMENTED PAN DEPTH (IN)	CEMENTED PAN HARDNESS	BEDROCK DEPTH (IN.)	BEDROCK HARDNESS	SUBSIDENCE INIT. (IN)	SUBSIDENCE TOTAL (IN)	HYD GRP	POTENT'L FROST ACTION
NONE			>2.0			-		>60		-		A	LOW

SANITARY FACILITIES

SEPTIC TANK ABSORPTION FIELDS	3-8%: SLIGHT 8+%: MODERATE-SLOPE
SEWAGE LAGOON AREAS	3-7%: SEVERE-SEEPAGE 7+%: SEVERE-SLOPE,SEEPAGE
SANITARY LANDFILL (TRENCH)	MODERATE-SEEPAGE,TOO SANDY
SANITARY LANDFILL (AREA)	MODERATE-SEEPAGE
DAILY COVER FOR LANDFILL	FAIR-TOO SANDY

SOURCE MATERIAL

ROADFILL	GOOD
SAND	POOR-EXCESS FINES
GRAVEL	UNSUITED
TOPSOIL	POOR-TOO SANDY

WATER MANAGEMENT

POND RESERVOIR AREA	SLOPE,SEEPAGE
EMBANKMENTS DIKES AND LEVEES	SEEPAGE,PIPING
EXCAVATED PONDS AQUIFER FED	NO WATER
DRAINAGE	
IRRIGATION	
TERRACES AND DIVERSIONS	SLOPE,PIPING,TOO SANDY
GRASSED WATERWAYS	

COMMUNITY DEVELOPMENT

SHALLOW EXCAVATIONS	SEVERE-CUTBANKS CAVE
DWELLINGS WITHOUT BASEMENTS	3-8%: SLIGHT 8+%: MODERATE-SLOPE
DWELLINGS WITH BASEMENTS	3-8%: SLIGHT 8+%: MODERATE-SLOPE
SMALL COMMERCIAL BUILDINGS	3-4%: SLIGHT 4-8%: MODERATE-SLOPE 8+%: SEVERE-SLOPE
LOCAL ROADS AND STREETS	3-8%: SLIGHT 8+%: MODERATE-SLOPE
LAWNS, LANDSCAPING AND GOLF FAIRWAYS	

REGIONAL INTERPRETATIONS

Table Q-12 (cont.)

RECREATION

CAMP AREAS	SEVERE-TOO SANDY	PLAYGROUNDS	3-6%: SEVERE-TOO SANDY 6+%: SEVERE-SLOPE,TOO SANDY
PICNIC AREAS	SEVERE-TOO SANDY	PATHS AND TRAILS	SEVERE-TOO SANDY

CAPABILITY AND PREDICTED YIELDS -- CROPS AND PASTURE (HIGH LEVEL MANAGEMENT)

CLASS-DETERMINING PHASE	CAPABILITY	NIRR	IRR.	NIRR	IRR.	NIRR	IRR.	NIRR	IRR.	NIRR	IRR.	NIRR	IRR.	NIRR	IRR.	NIRR	IRR.
ALL	7S																

WOODLAND SUITABILITY

CLASS-DETERMINING PHASE	ORD SYM	MANAGEMENT PROBLEMS: EROSION HAZARD	EQUIP. LIMIT	SEEDLING MORTALITY	WINDTH. HAZARD	PLANT COMPET.	POTENTIAL PRODUCTIVITY: IMPORTANT TREES	SITE IDX	TREES TO PLANT
							NONE		

WINDBREAKS

CLASS-DETERMINING PHASE	SPECIES	INT	SPECIES	INT	SPECIES	INT	SPECIES	INT
	NONE							

WILDLIFE HABITAT SUITABILITY

CLASS-DETERMINING PHASE	POTENTIAL FOR HABITAT ELEMENTS: GRAIN & SEED	GRASS & LEGUME	WILD HERB.	HARDWD TREES	CONIFER PLANTS	SHRUBS	POTENTIAL AS HABITAT FOR: WETLAND PLANTS	SHALLOW WATER	OPENLD WILDLF	WOODLD WILDLF	WETLAND WILDLF	RANGELD WILDLF
ALL	V. POOR	V. POOR	POOR	-	V. POOR	POOR	V. POOR	V. POOR	V. POOR	V. POOR	V. POOR	POOR

POTENTIAL NATIVE PLANT COMMUNITY (RANGELAND OR FOREST UNDERSTORY VEGETATION)

COMMON PLANT NAME	PLANT SYMBOL (NRCS)	PERCENTAGE COMPOSITION (DRY WEIGHT) BY CLASS DETERMINING PHASE: ALL
BLACK GRAMA	BOER4	5
CALLETA	HIJA	8
INDIAN RICEGRASS	ORHY	20
NEEDLEANDTHREAD	STCC4	5
SAND DROPSEED	SPCR	7
OTHER PERENNIAL GRASSES	PFGG	5
OTHER ANNUAL FORBS	AAFF	5
OTHER PERENNIAL FORBS	PFFF	5
BIG SAGEBRUSH	ARTR2	4
BUD SAGEBRUSH	ARSP5	4
FOURWING SALTBUSH	ATCA2	10
SHADSCALE	ATCO	4
BROOM SNAKEWEED	GUSA2	8
OTHER SHRUBS	SSSS	10
POTENTIAL PRODUCTION (LBS./AC. DRY WT):		
FAVORABLE YEARS		900
NORMAL YEARS		625
UNFAVORABLE YEARS		500

FOOTNOTES

A ESTIMATES BASED ON ENGINEERING TEST DATA ON ONE PEDON FOR SAN JUAN COUNTY, UTAH.

Table Q-12 (cont.)

NM0185 — SOIL SURVEY INTERPRETATIONS

MLRA(S): 37
TLP,CWK, 1-74
TYPIC HAPLARGIDS, COARSE-LOAMY, MIXED, MESIC

SHIPROCK SERIES

THE SHIPROCK SERIES CONSISTS OF DEEP, WELL-DRAINED SOILS. THEY FORMED IN ALLUVIAL DEPOSITS ON MESA TOPS AND UPLANDS. SLOPES ARE 0 TO 15 PERCENT. ELEVATIONS RANGE FROM 5300 TO 6600 FEET. MEAN ANNUAL PRECIPITATION RANGES FROM 6 TO 10 INCHES. MEAN ANNUAL AIR TEMPERATURES RANGE FROM 50 TO 54 DEGREES F, AND THE FROST-FREE SEASON IS 140 TO 160 DAYS. TYPICALLY, THE SURFACE LAYER IS A BROWN FINE SANDY LOAM, ABOUT 3 INCHES THICK. THE SUBSOIL IS A BROWN FINE SANDY LOAM, ABOUT 9 INCHES THICK. THE SUBSTRATUM IS A BROWN AND VERY PALE BROWN FINE SANDY LOAM AND SANDY LOAM TO 60 INCHES

ESTIMATED SOIL PROPERTIES (A)

DEPTH (IN.)	USDA TEXTURE	UNIFIED	AASHTO	FRACT >3 IN (PCT)	PERCENT OF MATERIAL LESS THAN 3" PASSING SIEVE NO. 4	10	40	200	LIQUID LIMIT	PLASTICITY INDEX
0-3	SL, FSL	SM, SM-SC	A-2, A-4	0	100	100	75-90	30-50	<30	NP-10
0-3	LS	SM, SP-SM	A-2, A-3	0	100	100	65-85	5-30	<30	NP-5
3-60	SL, FSL	SM, SM-SC	A-2, A-4	0	100	100	75-90	30-50	<30	NP-10

DEPTH (IN.)	PERMEABILITY (IN/HR)	AVAILABLE WATER CAPACITY (IN/IN)	SOIL REACTION (PH)	SALINITY (MMHOS/CM)	SHRINK-SWELL POTENTIAL	CORROSIVITY STEEL	CORROSIVITY CONCRETE	EROSION FACTORS K	EROSION FACTORS T	WIND EROD. GROUP
0-3	0.6-2.0	0.09-0.12	7.4-8.4	<2	LOW	HIGH	LOW	.24	5	3
0-3	2.0-6.0	0.06-0.09	7.4-8.4	<2	LOW	HIGH	LOW	.15	5	2
3-60	2.0-6.0	0.09-0.12	7.4-8.4	<4	LOW	HIGH	LOW	.24		

FLOODING FREQUENCY	FLOODING DURATION	FLOODING MONTHS	HIGH WATER TABLE DEPTH (FT)	HIGH WATER TABLE KIND	HIGH WATER TABLE MONTHS	CEMENTED PAN DEPTH (IN)	CEMENTED PAN HARDNESS	BEDROCK DEPTH (IN)	BEDROCK HARDNESS	SUBSIDENCE INIT. (IN)	SUBSIDENCE TOTAL (IN)	HYD GRP	POTENTIAL FROST ACTION
NONE			>6.0			>7		>60		-		B	LOW

SANITARY FACILITIES

SEPTIC TANK ABSORPTION FIELDS	0-8%: SLIGHT 8+%: MODERATE-SLOPE
SEWAGE LAGOON AREAS	0-7%: SEVERE-SEEPAGE 7+%: SEVERE-SLOPE,SEEPAGE
SANITARY LANDFILL (TRENCH)	SLIGHT
SANITARY LANDFILL (AREA)	0-8%: SLIGHT 8+%: MODERATE-SLOPE
DAILY COVER FOR LANDFILL	0-8%: GOOD 8+%: FAIR-SLOPE

COMMUNITY DEVELOPMENT

SHALLOW EXCAVATIONS	0-8%: SLIGHT 8+%: MODERATE-SLOPE
DWELLINGS WITHOUT BASEMENTS	0-8%: SLIGHT 8+%: MODERATE-SLOPE
DWELLINGS WITH BASEMENTS	0-8%: SLIGHT 8+%: MODERATE-SLOPE
SMALL COMMERCIAL BUILDINGS	0-4%: SLIGHT 4-8%: MODERATE-SLOPE 8+%: SEVERE-SLOPE
LOCAL ROADS AND STREETS	0-8%: MODERATE-LOW STRENGTH 8+%: MODERATE-SLOPE,LOW STRENGTH
LAWNS, LANDSCAPING AND GOLF FAIRWAYS	

SOURCE MATERIAL

ROADFILL	FAIR-LOW STRENGTH
SAND	POOR-EXCESS FINES
GRAVEL	UNSUITED
TOPSOIL	0-8% SL,FSL: GOOD LS: POOR-TOO SANDY 8+% SL,FSL: FAIR-SLOPE

WATER MANAGEMENT

POND RESERVOIR AREA	0-2%: SEEPAGE 2+%: SLOPE,SEEPAGE
EMBANKMENTS DIKES AND LEVEES	SEEPAGE,PIPING
EXCAVATED PONDS AQUIFER FED	NO WATER
DRAINAGE	0-1%: FAVORABLE 1+%: SLOPE
IRRIGATION	0-1%: DROUGHTY,FAST INTAKE,SOIL BLOWING 1+%: SLOPE,DROUGHTY,FAST INTAKE
TERRACES AND DIVERSIONS	0-4%: SOIL BLOWING 4+%: SLOPE,SOIL BLOWING
GRASSED WATERWAYS	

REGIONAL INTERPRETATIONS

RECREATION

CAMP AREAS	0-6%: MODERATE-DUSTY 6+%: MODERATE-DUSTY,SLOPE	PLAYGROUNDS	0-2%: MODERATE-DUSTY 2-6%: MODERATE-SLOPE,DUSTY 6+%: SEVERE-SLOPE
PICNIC AREAS	0-8%: MODERATE-DUSTY 8+%: MODERATE-DUSTY,SLOPE	PATHS AND TRAILS	MODERATE-DUSTY

CAPABILITY AND PREDICTED YIELDS -- CROPS AND PASTURE (HIGH LEVEL MANAGEMENT) (B)

CLASS-DETERMINING PHASE	CAPA-BILITY		ALFALFA HAY (TONS)		CORN SILAGE (TONS)		GRAIN SORGHUM (BU)		PASTURE (AUM)		CORN (BU)		APPLES (BU)			
	NIRR	IRR.	NIRR	IRR.	NIRR	IRR.	NIRR	IRR.	NIRR	IRR.	NIRR	IRR.	NIRR	IRR.	NIRR	IRR.
0-2% SL,FSL	7E	2E	-	7.0	-	21	-	107	-	14	-	119	-	700		
2-5% SL,FSL	7E	3E	-	7.0	-	21	-	107	-	14	-	119	-	700		
5-8% SL,FSL	7E	4E	-	6.4	-	19	-	102	-	12	-	111	-	700		
8+%	7E	-	-	-	-	-	-	-	-		-	-	-	-		
0-2% LS	7E	3E	-	6.6	-	18	-	94	-	13	-	105	-	630		
2-5% LS	7E	4E	-	6.6	-	18	-	94	-	13	-	105	-	630		

WOODLAND SUITABILITY

CLASS-DETERMINING PHASE	ORD SYM	MANAGEMENT PROBLEMS					POTENTIAL PRODUCTIVITY		
		EROSION HAZARD	EQUIP. LIMIT	SEEDLING MORT'Y.	WINDTH. HAZARD	PLANT COMPET.	IMPORTANT TREES	SITE INDEX	TREES TO PLANT
							NONE		

WINDBREAKS

CLASS-DETERMIN'G PHASE	SPECIES	HT	SPECIES	HT	SPECIES	HT	SPECIES	HT
IRR	ORIENTAL ARBORVITAE	10	SIBERIAN ELM	45	RUSSIAN-OLIVE	20	HACKBERRY	45
	MULTIFLORA ROSE	4	HONEYLOCUST	45	ROCKY MT. JUNIPER	23	EASTERN REDCEDAR	20

WILDLIFE HABITAT SUITABILITY

CLASS-DETERMINING PHASE	POTENTIAL FOR HABITAT ELEMENTS							POTENTIAL AS HABITAT FOR:				
	GRAIN & SEED	GRASS & LEGUME	WILD HERB.	HARDWD TREES	CONIFER PLANTS	SHRUBS	WETLAND PLANTS	SHALLOW WATER	OPENLD WILDLF	WOODLD WILDLF	WETLAND WILDLF	RANGELD WILDLF
ALL,NIRR	V. POOR	V. POOR	POOR	-	-	POOR	POOR	V. POOR	V. POOR	-	V. POOR	POOR
0-2% LS,IRR	FAIR	GOOD	POOR	-	-	POOR	FAIR	POOR	FAIR	-	POOR	POOR
2-5% LS,IRR	FAIR	GOOD	POOR	-	-	POOR	POOR	V. POOR	FAIR	-	V. POOR	POOR
0-2% SL,FSL,IRR	GOOD	GOOD	POOR	-	-	POOR	GOOD	POOR	FAIR	-	FAIR	POOR
2-5% SL,FSL,IRR	FAIR	GOOD	POOR	-	-	POOR	FAIR	V. POOR	FAIR	-	V. POOR	POOR
5-8% SL,FSL,IRR	FAIR	GOOD	POOR	-	-	POOR	POOR	V. POOR	FAIR	-	V. POOR	POOR

POTENTIAL NATIVE PLANT COMMUNITY (RANGELAND OR FOREST UNDERSTORY VEGETATION)

COMMON PLANT NAME	PLANT SYMBOL (NLSPN)	PERCENTAGE COMPOSITION (DRY WEIGHT) BY CLASS DETERMINING PHASE	
		SL,FSL	LS
WINTERFAT	EULA5	5	-
GIANT DROPSEED	SPGI	10	10
SAND DROPSEED	SPCR	5	5
INDIAN RICEGRASS	ORHY	25	15
OTHER PERENNIAL FORBS	PPFF	5	5
BLUE GRAMA	BOGR2	20	5
NEWMEXICO FEATHERGRASS	STNE2	5	5
BIG SAGEBRUSH	ARTR2	5	-
GALLETA	HIJA	5	-
LONGLEAF EPHEDRA	EPTR	5	5
FOURWING SALTBUSH	ATCA2	10	5
SAND BLUESTEM	ANHA	-	15
LITTLE BLUESTEM	ANSC2	-	15
SAND SAGEBRUSH	ARFI2	-	5
SIDEOATS GRAMA	BOCU	-	10
POTENTIAL PRODUCTION (LBS./AC. DRY WT):			
FAVORABLE YEARS		900	1200
NORMAL YEARS		600	800
UNFAVORABLE YEARS		300	400

FOOTNOTES

A ESTIMATES OF ENGINEERING PROPERTIES BASED ON ANALYTICAL DATA OF 8 PEDONS FROM SAN JUAN COUNTY, NEW MEXICO.

B PREDICTED YIELDS BASED ON SPRINKLE METHOD OF IRRIGATION ONLY.

SCS-SOILS-5
REV MAY 1972
FILE CODE SOILS-12

Table Q-12 (cont.)
(1)

U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

SOIL SURVEY INTERPRETATIONS

KEYING ONLY: RECORD NO. | CONTROL WORD NO. | MLRA 001 | STATE 011

MLRA(S) 27, 29 | KIND OF UNIT: Series | UNIT NAME: Stumble
STATE: New Mexico | RECORD NO. 76 | AUTHOR(S): EAN | DATE: 5/75 | REVISED: | UNIT MODIFIER:

CLASSIFICATION AND BRIEF SOIL DESCRIPTION

CLASS 021
DESCR 031: Stumble series consist of deep somewhat excessively drained soil forming in mixed sandy alluvium on alluvial fans. Their profiles have three parts: (1) light brownish-gray loamy sand, surface layer 6 inches thick, (2) light brownish-gray loamy sand 23 inches thick; and (3) light brownish-gray gravelly loamy sand to 50 inches. Elevations are 4000 to 6000 feet. M.A.A.T. is 47 to 55°F. MAP is 4 to 8 inches. Slopes are 0 to 8 percent.

ESTIMATED SOIL PROPERTIES

FOOTNOTE	DEPTH (IN	USDA TEXTURE	UNIFIED	AASHO	FRACT. >3 IN. (PCT)	PERCENT OF MATERIAL LESS THAN 3 IN. PASSING SIEVE 4	10	40	200	LIQUID LIMIT	PLASTICITY INDEX
PROP 041	0-6	LS, LFS	SM	A-2	0-5	85-100	85-100	55-75	15-25	<20	NP
	0-6	FSL	SM	A-4	0-5	85-100	85-100	65-85	35-45	<25	NP
	6-29	LS, LFS	SM	A-2	0-5	85-100	85-100	55-75	15-35	<20	NP
	29-50	GR-LS, GR-LFS	SM	A-2	0-10	75-85	50-70	40-50	15-25	<20	NP

	DEPTH (IN.)	PERMEABILITY (IN/HR)	AVAILABLE WATER CAPACITY (IN/IN)	SOIL REACTION (PH)	SALINITY (MMHOS/CM)	SHRINK-SWELL POTENTIAL	CORROSIVITY STEEL	CORROSIVITY CONCRETE	EROSION FACTORS K	EROSION FACTORS T	WIND EROD. GROUP
PROP 051	SAME DEPTH AS ABOVE	6.0-20	0.06 - 0.02	6.6-8.4	< 2	Low	High	Low	.17	5	2
		2.0-6.0	0.10 - 0.12	6.6-8.4	< 2	Low	High	Low	.28	5	3
		6.0-20	0.06 - 0.08	7.9-8.4	< 4	Low	High	Moderate	.17		
		6.0-20	0.04 - 0.06	7.9-9.0	< 8	Low	High	Moderate	.15		

	FLOODING FREQUENCY	FLOODING DURATION	FLOODING MONTHS	HIGH WATER TABLE DEPTH (FT)	HIGH WATER TABLE KIND	HIGH WATER TABLE MONTHS	CEMENTED PAN DEPTH (IN)	CEMENTED PAN HARDNESS	BEDROCK DEPTH (IN)	BEDROCK HARDNESS	SUBSIDENCE INITIAL (IN)	SUBSIDENCE TOTAL (IN)	HYD GRP	POTENTIAL FROST ACTION
PROP 061	None			>6.0			-		> 60				A	Low

SANITARY FACILITIES

	FOOTNOTES	
SEPTIC 071	SEPTIC TANK ABSORPTION FIELDS	Slight
LAGOON 021	SEWAGE LAGOONS	0-7%: Severe - seepage 7+%: Severe - slope, seepage
TRENCH 031	SANITARY LANDFILL (TRENCH)	Moderate - too sandy
SANARE 101	SANITARY LANDFILL (AREA)	Slight
COVER 111	DAILY COVER FOR LANDFILL	Fair - too sandy

COMMUNITY DEVELOPMENT

	FOOTNOTES	
EXCAV 121	SHALLOW EXCAVATIONS	Severe - cutbanks cave
DWEL 131	DWELLINGS WITHOUT BASEMENTS	Slight
DWEL 141	DWELLINGS WITH BASEMENTS	Slight
BLDGS 151	SMALL COMMERCIAL BUILDINGS	0-4%: slight 4-8%: Moderate - slope
ROADS 161	LOCAL ROADS AND STREETS	Slight

REGIONAL INTERPRETATIONS

	FOOTNOTES	
REGION 171		
REGION 181		

SOURCE MATERIAL

KEYING ONLY	FOOTNOTES	
FILL 191	ROADFILL	Good
SAND 201	SAND	Poor - excess fines
GRAVEL 211	GRAVEL	Unsuited - excess fines
SOIL 221	TOPSOIL	LS, LFS: Poor - too sandy FSL: Poor - thin layer

WATER MANAGEMENT

KEYING ONLY	FOOTNOTES	
PONDRS 231	POND RESERVOIR AREA	0-2% : seepage 2+%: seepage, slope
DIKES 241	EMBANKMENTS DIKES AND LEVEES	Seepage, piping
PONDAQ 251	EXCAVATED PONDS AQUIFER FED	No water
DRAIN 261	DRAINAGE	0-2% : Cutbanks cave 2+%: slope, cutbanks cave
IRRIG 271	IRRIGATION	0-2%: Droughty seepage, soil blowing 2+%: Droughty, slope, soil blowing
TERRAC 281	TERRACES AND DIVERSIONS	0-2%: Piping, soil blowing, too sandy 2+%: Piping, soil blowing, slope
WATERW 291	GRASSED WATERWAYS	

Table Q-12 (cont.)

KEYING ONLY: RECORD NO. | CONTROL

UNIT NAME Stubble
UNIT MODIFIER

(2)

RECREATION

KEYING ONLY		FOOTNOTE		FOOTNOTE
CAMPS 321	CAMP AREAS	FSL: Slight LS, LFS: Severe - soil blowing	PLAYGD 321	PLAYGROUNDS	0-2% FSL: Slight 2-6% FSL: Moderate - slope 6+% FSL: Severe - slope 0-6% LS,LFS: Severe - soil blowing 6+% LS, LFS: Severe - soil blowing, slope
PICNIC 311	PICNIC AREAS	FSL: Slight LS, LFS: Severe - soil blowing	PATHS 311	PATHS AND TRAILS	FSL : Slight LS, LFS: Moderate - too sandy

CAPABILITY AND PREDICTED YIELDS CROPS AND PASTURE (HIGH LEVEL MANAGEMENT)

FOOTNOTE

CLASS-DETERMINING PHASE	CAPABILITY NIRR	CAPABILITY IRR.														
All	7S	3S														

WOODLAND SUITABILITY

FOOTNOTE

CLASS-DETERMINING PHASE	ORD SYM	MANAGEMENT PROBLEMS: EROSION HAZARD	EQUIP. LIMIT	SEEDLING MORT'Y.	WINDTH. HAZARD	PLANT COMPET.	POTENTIAL PRODUCTIVITY: IMPORTANT TREES	SITE INDEX	TREES TO PLANT
							None		

WIND BREAKS

FOOTNOTE

CLASS-DETERMINING PHASE	SPECIES	HT	SPECIES	HT	SPECIES	HT	SPECIES	HT
All	Golden Willow	40	Russian-Olive	30	Athel	25	Rocky Mt. Juniper	25

WILDLIFE HABITAT SUITABILITY

FOOTNOTE

CLASS-DETERMINING PHASE	POTENTIAL FOR HABITAT ELEMENTS: GRAIN & SEED	GRASS & LEGUME	WILD HERB.	HARDWD TREES	CONIFER PLANTS	SHRUBS	WETLAND PLANTS	SHALLOW WATER	POTENTIAL AS HABITAT FOR: OPENLAND WILDLIFE	WOODLAND WILDLIFE	WETLAND WILDLIFE	RANGELAND WILDLIFE
IRR	Fair	Good	Good	Fair	--	Good	V.Poor	V.Poor	Fair	Fair	V.Poor	Good
HIRR	--	--	Fair	--	--	Fair	--	--	--	--	--	Fair

POTENTIAL NATIVE PLANT COMMUNITY (RANGELAND OR FOREST UNDERSTORY VEGETATION)

FOOTNOTE

COMMON PLANT NAME	PLANT SYMBOL (NLSPN)	PERCENTAGE COMPOSITION (DRY WEIGHT) BY CLASS DETERMINING PHASE: PP, FF LS	DS LFS, FSL
Bailly Grease wood	SAVE8	15	--
Fourwing saltbush	ATCA2	15	20
Winterfat	EULA5	10	5
Indian ricegrass	ORHY	40	20
Sand dropseed	SPCR	--	20
Desert needlegrass	STSP3	3	
Littleleaf horsebrush	TEGL	2	10
Spiny Hopsage	GRSP	5	2
Datil	DAFE4	--	5
PPGG	PPGG	--	5
AAGG	AAGG	--	3
SSSS	SSSS	5	5
AAFF	AAFF	3	3
PPFF	PPFF	2	2
POTENTIAL PRODUCTION (LBS./AC. DRY WT) FAVORABLE YEARS		600	400
NORMAL YEARS		400	300
UNFAVORABLE YEARS		250	250

FOOTNOTES

SYM.

A Arid climate - permeability not used as criteria.

Table Q-12 (cont.)

NM0191 — SOIL SURVEY INTERPRETATIONS

MLRA(S): 37
TLP,CWK, 1-74
TYPIC TORRIORTHENTS, FINE-LOAMY, MIXED (CALCAREOUS), MESIC

TURLEY SERIES

THE TURLEY SERIES CONSISTS OF DEEP, WELL-DRAINED SOILS. THEY FORMED ON ALLUVIAL FANS IN VALLEY-FILLING SIDE SLOPES FROM MIXED ALLUVIUM. SLOPES ARE FROM 0 TO 5 PERCENT. ELEVATIONS RANGE FROM 4800 TO 6000 FEET. MEAN ANNUAL PRECIPITATION RANGES FROM 6 TO 10 INCHES. MEAN ANNUAL AIR TEMPERATURES RANGE FROM 50 TO 54 DEGREES F, AND THE FROST-FREE SEASON IS ABOUT 155 DAYS. TYPICALLY, THE SURFACE LAYER IS A GRAYISH-BROWN CLAY LOAM, ABOUT 3 INCHES THICK. THE UNDERLYING MATERIAL IS A LIGHT YELLOWISH-BROWN CLAY LOAM AND PALE YELLOW SANDY CLAY LOAM; TO 80 INCHES

ESTIMATED SOIL PROPERTIES (A)

DEPTH (IN.)	USDA TEXTURE	UNIFIED	AASHTO	FRACT >3 IN (PCT)	PERCENT OF MATERIAL LESS THAN 3" PASSING SIEVE NO. 4	10	40	200	LIQUID LIMIT	PLASTICITY INDEX
0-3	L	ML, CL-ML	A-4	0	100	100	85-100	60-75	25-35	5-10
0-3	CL	CL	A-6	0	100	100	85-100	65-80	30-40	10-20
3-57	CL, SICL	CL	A-6	0	100	100	85-100	65-80	30-40	10-20
57-80	SCL	SC, CL, SM-SC, CL-ML	A-4, A-6	0	100	100	80-90	35-65	25-35	5-15

DEPTH (IN.)	PERMEABILITY (IN/HR)	AVAILABLE WATER CAPACITY (IN/IN)	SOIL REACTION (PH)	SALINITY (MMHOS/CM)	SHRINK-SWELL POTENTIAL	CORROSIVITY STEEL	CORROSIVITY CONCRETE	EROSION FACTORS K	EROSION FACTORS T	WIND EROD. GROUP
0-3	0.6-2.0	0.14-0.17	7.4-8.4	2-4	LOW	HIGH	LOW	.28	5	4L
0-3	0.2-0.6	0.15-0.19	7.4-8.4	2-4	MODERATE	HIGH	LOW	.28	5	4L
3-57	0.2-0.6	0.15-0.19	7.4-8.4	2-4	MODERATE	HIGH	LOW	.28		
57-80	0.6-2.0	0.14-0.16	7.4-8.4	2-4	MODERATE	HIGH	LOW	.28		

FLOODING FREQUENCY	FLOODING DURATION	FLOODING MONTHS	HIGH WATER TABLE DEPTH (FT)	HIGH WATER TABLE KIND	HIGH WATER TABLE MONTHS	CEMENTED PAN DEPTH (IN)	CEMENTED PAN HARDNESS	BEDROCK DEPTH (IN)	BEDROCK HARDNESS	SUBSIDENCE INIT. (IN)	SUBSIDENCE TOTAL (IN)	HYD GRP	POTENTIAL FROST ACTION
NONE			>6.0			-		>60		-		B	LOW

SANITARY FACILITIES

SEPTIC TANK ABSORPTION FIELDS	MODERATE-PERCS SLOWLY
SEWAGE LAGOON AREAS	0-2%: SLIGHT 2+%: MODERATE-SLOPE
SANITARY LANDFILL (TRENCH)	SLIGHT
SANITARY LANDFILL (AREA)	SLIGHT
DAILY COVER FOR LANDFILL	FAIR-TOO CLAYEY

COMMUNITY DEVELOPMENT

SHALLOW EXCAVATIONS	MODERATE-TOO CLAYEY
DWELLINGS WITHOUT BASEMENTS	MODERATE-SHRINK-SWELL
DWELLINGS WITH BASEMENTS	MODERATE-SHRINK-SWELL
SMALL COMMERCIAL BUILDINGS	0-4%: MODERATE-SHRINK-SWELL 4+%: MODERATE-SHRINK-SWELL,SLOPE
LOCAL ROADS AND STREETS	MODERATE-LOW STRENGTH,SHRINK-SWELL
LAWNS, LANDSCAPING AND GOLF FAIRWAYS	

SOURCE MATERIAL

ROADFILL	FAIR-LOW STRENGTH,SHRINK-SWELL
SAND	UNSUITED
GRAVEL	UNSUITED
TOPSOIL	FAIR-TOO CLAYEY

WATER MANAGEMENT

POND RESERVOIR AREA	0-2%: FAVORABLE 2+%: SLOPE
EMBANKMENTS DIKES AND LEVEES	LOW STRENGTH,SHRINK-SWELL,PIPING
EXCAVATED PONDS AQUIFER FED	NO WATER
DRAINAGE	0-1%: PERCS SLOWLY 1+%: SLOPE,PERCS SLOWLY
IRRIGATION	0-1%: PERCS SLOWLY 1-5%: ERODES EASILY,SLOPE,PERCS SLOWLY
TERRACES AND DIVERSIONS	PERCS SLOWLY,PIPING
GRASSED WATERWAYS	

REGIONAL INTERPRETATIONS

RECREATION

CAMP AREAS	CL: MODERATE-PERCS SLOWLY,TOO CLAYEY L: MODERATE-PERCS SLOWLY	PLAYGROUNDS	0-2% CL: MODERATE-PERCS SLOWLY,TOO CLAYEY 0-2% L: MODERATE-PERCS SLOWLY 2+% CL: MODERATE-PERCS SLOWLY,SLOPE,TOO CLAYEY 2+% L: MODERATE-SLOPE,TOO CLAYEY
PICNIC AREAS	CL: MODERATE-TOO CLAYEY L: SLIGHT	PATHS AND TRAILS	CL: MODERATE-TOO CLAYEY L: SLIGHT

CAPABILITY AND PREDICTED YIELDS -- CROPS AND PASTURE (HIGH LEVEL MANAGEMENT)

CLASS-DETERMINING PHASE	CAPABILITY		ALFALFA HAY (TONS)		CORN (BU)		CORN SILAGE (TONS)		GRASS HAY (TONS)		GRAIN SORGHUM (BU)		PASTURE (AUM)		APPLES (BU)	
	NIRR	IRR.	NIRR	IRR.	NIRR	IRR.	NIRR	IRR.	NIRR	IRR.	NIRR	IRR.	NIRR	IRR.	NIRR	IRR.
0-1%	7C	2C	-	6.8	-	115	-	19.6	-	5	-	105	-	14	-	730
1-3%	7E	2E	-	6.8	-	108	-	18.6	-	5	-	93	-	13	-	730
3+%	7E	3E	-	6.0	-	95	-	16.3	-	4	-	75	-	12	-	695

WOODLAND SUITABILITY

CLASS-DETERMINING PHASE	ORD SYM	MANAGEMENT PROBLEMS: EROSION HAZARD	EQUIP. LIMIT	SEEDLING MORT. %	WINDTH. HAZARD	PLANT COMPET.	POTENTIAL PRODUCTIVITY: IMPORTANT TREES	SITE INDX	TREES TO PLANT
							NONE		

WINDBREAKS

CLASS-DETERMIN'G PHASE	SPECIES	HT	SPECIES	HT	SPECIES	HT	SPECIES	HT
IRR	ORIENTAL ARBORVITAE	10	SIBERIAN ELM	45	RUSSIAN-OLIVE	20	HACKBERRY	45
	MULTIFLORA ROSE	4	HONEYLOCUST	45	ROCKY MT. JUNIPER	23	EASTERN REDCEDAR	20

WILDLIFE HABITAT SUITABILITY

CLASS-DETERMINING PHASE	POTENTIAL FOR HABITAT ELEMENTS: GRAIN & SEED	GRASS & LEGUME	WILD HERB.	HARDWD TREES	CONIFER PLANTS	SHRUBS	WETLAND PLANTS	SHALLOW WATER	POTENTIAL AS HABITAT FOR: OPENLD WILDLF	WOODLD WILDLF	WETLAND WILDLF	RANGELD WILDLF
1-3% IRR	GOOD	GOOD	POOR	-	-	POOR	GOOD	POOR	FAIR	-	FAIR	POOR
3+% IRR	FAIR	GOOD	POOR	-	-	POOR	POOR	V. POOR	FAIR	-	V. POOR	POOR
NIRR	V. POOR	V. POOR	POOR	-	-	POOR	POOR	V. POOR	V. POOR	-	V. POOR	POOR
0-1% IRR	GOOD	GOOD	POOR	-	-	POOR	GOOD	FAIR	FAIR	-	FAIR	POOR

POTENTIAL NATIVE PLANT COMMUNITY (RANGELAND OR FOREST UNDERSTORY VEGETATION)

COMMON PLANT NAME	PLANT SYMBOL (NLSPN)	PERCENTAGE COMPOSITION (DRY WEIGHT) BY CLASS DETERMINING PHASE: ALL
BIG SAGEBRUSH	ARTR2	5
BLUE GRAMA	BOGR2	20
FOURWING SALTBUSH	ATCA2	5
OTHER PERENNIAL FORBS	PPFF	5
GALLETA	HIJA	15
INDIAN RICEGRASS	ORHY	5
NEEDLEANDTHREAD	STCO4	5
WESTERN WHEATGRASS	AGSM	20
ALKALI SACATON	SPAI	20
POTENTIAL PRODUCTION (LBS./AC. DRY WT):		
FAVORABLE YEARS		750
NORMAL YEARS		500
UNFAVORABLE YEARS		300

FOOTNOTES

A ENGINEERING PROPERTIES ESTIMATES BASED ON DATA FROM 10 INDIVIDUAL HORIZON SAMPLES FROM SAN JUAN COUNTY, NEW MEXICO.
1 RATE MODERATE DUE TO SEMI ARID CLIMATE.

Table 0-13

7-2006A (6-76)
Bureau of Reclamation

U.S. BUREAU OF RECLAMATION

POINT SITE LAND CHARACTERIZATION

(WITH DETERMINATIONS)

Study Area: Kimbeto
Location: Sec. 7 Twp. 22N Range 10W
1,950' W, 2,050' S, NE corner - Profile 62
Climate: Arid
Land Use: Rangeland

Relief: Hilly
Elevation: 6200
Slope: Aspect:
Vegetation:
Erosion:

Stoniness:
Drainage:
Ground Water: None
Land Form: Badlands

Parent Material: Alluvial
Soil Series: Phases & variations of ~~several series~~
Soil Classification 6 -ap
-6j
Profile Description By R.G. Moore Date 10/76

LAB NO.	DEPTH (Cm.)	PROFILE DESCRIPTION
115	0-60	Loamy fine sand, dry, 5Y 5/3 olive, weak granular, slightly hard, nonsticky and nonplastic
116	60-150	Loam, dry, 5Y 7/2 light gray, weak blocky, very hard, very slightly sticky and very slightly plastic
117	150-255	Sand, dry, 5Y 6/3 pale olive, weak granular, slightly loose, nonsticky and nonplastic
118	255-300	Shale, dry, 5Y 7/4 pale yellow, moderate massive, very hard, sticky and plastic

LABORATORY DESCRIPTION

DETERMINATION		DATA			
LABORATORY NUMBER		115	116	117	118
DEPTH	(cm)	0-60	60-150	150-205	205-300
PARTICLE SIZE ANALYSIS	(percent)				
Very Coarse Sand	(2.0-1.0mm)				
Coarse Sand	(1.0-0.5mm)				
Medium Sand	(0.5-0.25mm)				
Fine Sand	(0.25-0.10mm)				
Very Fine Sand	(0.10-0.05mm)				
Total Sand	(2.0-0.05mm)	72.0	51.4	84.4	34.4
Silt	(0.05-0.002mm)	18.6	32.0	9.2	37.2
Clay	(<0.002mm)	9.4	16.6	6.4	28.4
TEXTURAL CLASS (LAB)		SL	L	LS	CL
BULK DENSITY	(g/cm^3)				
HYDRAULIC CONDUCTIVITY	(cm/hr)				
6^{th} hr		.80	0.0	0.0	0.0
24^{th} hr		1.20	0.0	0.0	0.0
SETTLING VOLUME	(ml)	17	21	17	320
MOISTURE RETENTION	(percent)				
1/10 bar					
1/3 bar					
15 bar		4.0	6.3	5.0	20.8
SOIL REACTION-pH					
Paste					
1:5 H_2O		9.4	9.3	9.9	10.0
1:2 0.01 M $CaCl_2$		7.0	7.1	7.1	7.7
ORGANIC CARBON	(percent)				
AVAILABLE PHOSPHORUS	(ppm)				
$CaCO_3$ EQUIVALENT	(percent)				
GYPSUM REQUIREMENT	(me/100g)				
SATURATION EXTRACT					
Saturation Percentage		27.2	33.7	26.9	84.3
EC_e @ 25°C	(mmhos/cm)	.71	1.9	1.7	7.5
Ca^{++} & Mg ++	(me/l)	2.0	3.8	1.4	15.6
Mg^{++}	(me/l)				
Na^{+}	(me/l)	4.9	14.4	13.6	68.0
K^{+}	(me/l)				
CO_3^{-}	(me/l)				
HCO_3^{-}	(me/l)				
Cl^{-}	(me/l)				
SO_4^{-}	(me/l)				
NO_3^{-}	(me/l)				
SAR		4.9	10.4	16.3	24.4
Na	(me/100g)				
Ca+Mg	(me/100g)				
1:5 EXTRACT					
EC_5 @ 25°C	(mmhos/cm)	1.1	.25	.19	.37
Ca+Mg	(me/l)				
EXCHANGEABLE SODIUM	(percent)	8.2	14.4	23.7	21.8
ACIDITY					
IN KCl exchange acidity					
Total	(me/100g)				
Al^{+++}	(me/100g)				
CATION EXCHANGE CAPACITY	(me/100g)	10.6	14.6	7.6	31.6
NaOAc@pH 8.2					
BORON	(mg/l)				

GPO 838-788

7-2006A (6-76)
Bureau of Reclamation

Table Q-13 (cont.)

U.S BUREAU OF RECLAMATION

POINT SITE LAND CHARACTERIZATION

(WITH DETERMINATIONS)

Study Area: Kimberg
Location Sec. 25 Twp. 22N Range 10W
2,000' W, 1,650' S, NE corner - Profile 15
Climate: Arid
Land Use: Rangeland

Relief: Slightly undulating
Elevation: 5980
Slope: Aspect:
Vegetation:
Erosion:

Stoniness: None
Drainage:
Ground Water: None
Land Form: Valley

Parent Material: Alluvial and eolian
Soil Series: Stumble - Turley - Notal Association
Soil Classification: $6_{10}^{6s\ p}$
Profile Description By: R.G. Moore Date: 10/76

LAB NO.	DEPTH (Cm.)	PROFILE DESCRIPTION
181	0-30	Fine sand, moist, 2.5Y 4/4 olive brown, single grain, loose, nonsticky and nonplastic
182	30-90	Fine sand, dry, 2.5Y 7/2 light grey, single grain, slightly hard, nonsticky and nonplastic
183	90-165	Loamy fine sand, dry 10YR 4/4 dark yellowish-brown, single grain very slightly hard, nonsticky and nonplastic
184	165-235	Clay loam, dry 2.5Y 5/2 grayish-brown, moderate granular, slightly soft, slightly sticky and slightly plastic
	235-270	Sandstone, dry 5Y 7/1 light gray, moderate massive, slightly hard, nonsticky and nonplastic

LABORATORY DESCRIPTION

DETERMINATION		181	182	183	184
LABORATORY NUMBER					
DEPTH	(cm)	0-30	30-90	90-165	165-270
PARTICLE SIZE ANALYSIS	(percent)				
Very Coarse Sand	(2.0-1.0mm)				
Coarse Sand	(1.0-0.5mm)				
Medium Sand	(0.5-0.25mm)				
Fine Sand	(0.25-0.10mm)				
Very Fine Sand	(0.10-0.05mm)				
Total Sand	(2.0-0.05mm)	84.4	88.2	79.4	49.8
Silt	(0.05-0.002mm)	12.0	6.2	13.0	30.6
Clay	(<0.002 mm)	3.6	5.6	7.6	19.6
TEXTURAL CLASS (LAB)		LS	LS	LS	L
BULK DENSITY	(g/cm^3)				
HYDRAULIC CONDUCTIVITY	(cm/hr)				
6^{th} hr		8.4	0.0	0.0	0.0
24^{th} hr		1.5	0.0	0.0	0.0
SETTLING VOLUME	(ml)	16	16	18	3.4
MOISTURE RETENTION	(percent)				
1/10 bar					
1/3 bar					
15 bar		3.0	4.1	4.3	9.6
SOIL REACTION-pH					
Paste					
1:5 H_2O		7.9	9.5	9.5	9.2
1:2 0.01 M $CaCl_2$		6.3	6.9	7.3	7.7
ORGANIC CARBON	(percent)				
AVAILABLE PHOSPHORUS	(ppm)				
$CaCO_3$ EQUIVALENT	(percent)				
GYPSUM REQUIREMENT	(me/100g)				
SATURATION EXTRACT					
Saturation Percentage		28.2	50.7	34.9	36.4
EC_e @ 25°C	(mmhos/cm)	.56	5.2	6.7	12.2
Ca^{++} & Mg^{++}	(me/l)	5.4	8.0	7.6	22.6
Mg^{++}	(me/l)				
Na^{+}	(me/l)	1.8	54.4	71.0	112.0
K^{+}	(me/l)				
CO_3^{-}	(me/l)				
HCO_3^{-}	(me/l)				
Cl^{-}	(me/l)				
SO_4^{-}	(me/l)				
NO_3^{-}	(me/l)				
SAR		1.1	27.2	36.4	33.3
Na	(me/100g)				
Ca+Mg	(me/100g)				
1:5 EXTRACT					
EC_5 @ 25°C	(mmhos/cm)	.08	.46	.77	1.2
Ca+Mg	(me/l)				
EXCHANGEABLE SODIUM	(percent)	2.7	5.2	25.0	32.6
ACIDITY					
IN KCl exchange acidity					
Total	(me/100g)				
Al^{+++}	(me/100g)				
CATION EXCHANGE CAPACITY	(me/100g)	7.0	5.4	14.8	24.2
NaOAc@pH 8.2					
BORON	(mg/l)				

GPO 838-788

Table Q-13 (cont.)

7-2006A (6-76)
Bureau of Reclamation

U.S. BUREAU OF RECLAMATION

POINT SITE LAND CHARACTERIZATION
(WITH DETERMINATIONS)

Study Area: Kimbeto | Relief: Very gently rolling | Stoniness: None | Parent Material: Eolian and alluvial
Location. Sec. 27 Twp. 22N Range 10W | Elevation: 5980 | | Soil Series: Doak, Shiprock, Sheppard Association
2,150' S, 1,900' W, NE Corner - Profile 29 | Slope: Aspect: | Drainage: | Soil Classification $\frac{1}{1}\frac{2}{7}\frac{v}{2}$
Climate: Arid | Vegetation: | Ground Water: None
Land Use: Rangeland | Erosion: | Land Form: Mesa | Profile Description By: R.G. Moore Date 10/76

LAB NO.	DEPTH (Cm.)	PROFILE DESCRIPTION
200	0-30	Loam, dry, 10 YR 5/6 yellowish brown, moderate granular, slightly soft, very slightly sticky and very slightly plastic
201	30-90	Sandy loam, dry, 10 YR 5/4, yellowish brown, moderate granular, very slightly hard, nonsticky and nonplastic
202	90-205	Loamy fine sand, dry, 10 YR 6/4, light yellowish brown, weak single grain, very slightly hard, nonsticky and nonplastic
203	205-300	Sand, dry, 10 YR 8/3, very pale brown, moderate single grain, slightly loose, nonsticky and nonplastic

LABORATORY DESCRIPTION

DETERMINATION		DATA			
LABORATORY NUMBER		200	201	202	203
DEPTH	(cm)	0-30	30-90	90-205	205-300
PARTICLE SIZE ANALYSIS	(percent)				
Very Coarse Sand	(2.0-1.0mm)				
Coarse Sand	(1.0-0.5mm)				
Medium Sand	(0.5-0.25mm)				
Fine Sand	(0.25-0.10mm)				
Very Fine Sand	(0.10-0.05mm)				
Total Sand	(2.0-0.05mm)	68.0	63.4	75.4	72.6
Silt	(0.05-0.002mm)	20.4	24.0	15.0	24.8
Clay	(<0.002mm)	11.6	12.6	9.6	2.6
TEXTURAL CLASS (LAB)		SL	SL	SL	LS/SL
BULK DENSITY	(g/cm^3)				
HYDRAULIC CONDUCTIVITY	(cm/hr)				
6th hr		2.7	.36	.44	12.2
24th hr		2.9	.44	.70	3.2
SETTLING VOLUME	(ml)	15	17	15	15
MOISTURE RETENTION	(percent)				
1/10 bar					
1/3 bar					
15 bar		6.3	6.8	4.6	3.6
SOIL REACTION-pH					
Paste					
1:5 H_2O		6.9	8.4	9.0	9.2
1:2 0.01 M $CaCl_2$		7.4	7.3	7.8	7.7
ORGANIC CARBON	(percent)				
AVAILABLE PHOSPHORUS	(ppm)				
$CaCO_3$ EQUIVALENT	(percent)				
GYPSUM REQUIREMENT	(me/100g)				
SATURATION EXTRACT					
Saturation Percentage		26.9	26.1	23.5	21.5
EC_e @ 25°C	(mmhos/cm)	.38	.80	4.5	3.3
$Ca^{++} + Mg^{++}$	(me/l)	3.1	2.2	9.2	13.3
Mg^{++}	(me/l)				
Na^{+}	(me/l)	0.65	8.0	39.0	26.0
K^{+}	(me/l)				
CO_3^{-}	(me/l)				
HCO_3^{-}	(me/l)				
Cl^{-}	(me/l)				
SO_4^{-}	(me/l)				
NO_3^{-}	(me/l)				
SAR		.5	7.7	18.2	10.1
Na	(me/100g)				
Ca+Mg	(me/100g)				
1:5 EXTRACT					
EC_5 @ 25°C	(mmhos/cm)	.06	.15	.35	.23
Ca+Mg	(me/l)				
EXCHANGEABLE SODIUM	(percent)	1.3	9.3	24.3	17.8
ACIDITY					
IN KCl exchange acidity					
Total	(me/100g)				
Al^{+++}	(me/100g)				
CATION EXCHANGE CAPACITY	(me/100g)	10.4	10.6	7.0	3.6
NaOAc@pH 8.2					
BORON	(mg/l)				

GPO 838-768

Table Q-13 (cont.)

7-2006A (6-76)
Bureau of Reclamation

U.S. BUREAU OF RECLAMATION

POINT SITE LAND CHARACTERIZATION

(WITH DETERMINATIONS)

Study Area: Kimbeto
Location Sec. 24 Twp. 22N Range 10W
450' S, 2,500' E, NW Corner - Profile 30
Climate: Arid
Land Use: Rangeland

Relief: Undulating and hummocky
Elevation: 5980
Slope: Aspect:
Vegetation:
Erosion:

Stoniness: None
Drainage:
Ground Water: None
Land Form: Miscellaneous Hummocky

Parent Material: Alluvial
Soil Series: Fruitland-Persayo-Sheppard Complex
Soil Classification $\frac{6s\ av}{6_5}$
Profile Description By R.G. Moore Date 10/76

LAB NO.	DEPTH (Cm.)	PROFILE DESCRIPTION
204	0-60	Fine sand, moist, 10 YR 6/3, pale brown, single grain, slightly loose, nonsticky and nonplastic
205	60-150	Fine sand, dry, 10 YR 6/3, pale brown, strong single grain, slightly hard, nonsticky and nonplastic

LABORATORY DESCRIPTION			
DETERMINATION		DATA	
LABORATORY NUMBER		204	205
DEPTH	(cm)	0-60	60-150
PARTICLE SIZE ANALYSIS	(percent)		
Very Coarse Sand	(2.0-1.0mm)		
Coarse Sand	(1.0-0.5mm)		
Medium Sand	(0.5-0.25mm)		
Fine Sand	(0.25-0.10mm)		
Very Fine Sand	(0.10-0.05mm)		
Total Sand	(2.0-0.05mm)	86.2	93.8
Silt	(0.05-0.002mm)	12.0	4.6
Clay	(<0.002mm)	1.8	1.6
TEXTURAL CLASS (LAB)		S/LS	S
BULK DENSITY	(g/cm^3)		
HYDRAULIC CONDUCTIVITY	(cm/hr)		
6^{th} hr		5.0	4.6
24^{th} hr		1.9	2.4
SETTLING VOLUME	(ml)	15	16
MOISTURE RETENTION	(percent)		
1/10 bar			
1/3 bar			
15 bar		0.2	9.5
SOIL REACTION-pH			
Paste			
1:5 H_2O		8.5	9.8
1:2 0.01 M $CaCl_2$		7.4	7.6
ORGANIC CARBON	(percent)		
AVAILABLE PHOSPHORUS	(ppm)		
$CaCO_3$ EQUIVALENT	(percent)		
GYPSUM REQUIREMENT	(me/100g)		
SATURATION EXTRACT			
Saturation Percentage		23.0	28.4
EC_e @ 25°C	(mmhos/cm)	.64	.52
$Ca^{++} + Mg^{++}$	(me/l)	4.3	.78
Mg^{++}	(me/l)		
Na^{+}	(me/l)	1.7	6.0
K^{+}	(me/l)		
CO_3^{-}	(me/l)		
HCO_3^{-}	(me/l)		
Cl^{-}	(me/l)		
SO_4^{-}	(me/l)		
NO_3^{-}	(me/l)		
SAR		1.3	9.6
Na	(me/100g)		
Ca+Mg	(me/100g)		
1:5 EXTRACT			
EC_5 @ 25°C	(mmhos/cm)	.05	.09
Ca+Mg	(me/l)		
EXCHANGEABLE SODIUM	(percent)	2.4	35.3
ACIDITY			
1N KCl exchange acidity			
Total	(me/100g)		
Al^{+++}	(me/100g)		
CATION EXCHANGE CAPACITY	(me/100g)	3.4	3.4
NaOAc@pH 8.2			
BORON	(mg/l)		

GPO 698-788

7-2006A (6-76)
Bureau of Reclamation

Table Q-13 (cont.)

U.S BUREAU OF RECLAMATION
POINT SITE LAND CHARACTERIZATION
(WITH DETERMINATIONS)

Study Area: Kimbero
Location. Sec. 16 Twp. 22N Range 10W
1,550' W, 1,900' N, SE corner - Profile 58
Climate. Arid
Land Use: Rangeland

Relief: Long very gentle slope
Elevation: 5960
Slope: Aspect:
Vegetation:
Erosion:

Stoniness: None
Drainage:
Ground Water: None
Land Form: Valley S-A

Parent Material: Alluvial
Soil Series: Blancot - Notal Association
Soil Classification 6s p / 6/10
Profile Description By: R.C. Moore Date 10/76

LAB NO.	DEPTH (Cm.)	PROFILE DESCRIPTION
233	0-15	Clay loam, dry, 5Y 6/3 pale olive, weak blocky, slightly hard, slightly sticky and slightly plastic
234	15-120	Loamy fine sand, dry, 5Y 7/2 light gray, moderate granular, slightly hard, nonsticky and nonplastic
235	120-210	Fine sand, dry, 5Y 7/3 pale yellow, moderate granular, very hard, nonsticky and nonplastic
236	210-300	Fine sandy loam, dry, 5Y 6/3 pale olive, moderate granular, very hard, nonsticky and nonplastic

LABORATORY DESCRIPTION					
DETERMINATION		DATA			
LABORATORY NUMBER		233	234	235	236
DEPTH	(cm)	0-15	15-120	120-210	210-300
PARTICLE SIZE ANALYSIS	(percent)				
Very Coarse Sand	(2.0-1.0mm)				
Coarse Sand	(1.0-0.5mm)				
Medium Sand	(0.5-0.25mm)				
Fine Sand	(0.25-0.10mm)				
Very Fine Sand	(0.10-0.05mm)				
Total Sand	(2.0-0.05mm)	67.0	70.6	74.6	71.6
Silt	(0.05-0.002mm)	18.8	22.2	16.2	18.2
Clay	(<0.002mm)	14.2	7.2	9.2	10.2
TEXTURAL CLASS (LAB)		SL	SL	SL	SL
BULK DENSITY	(g/cm^3)				
HYDRAULIC CONDUCTIVITY	(cm/hr)				
6^{th} hr		0.0	1.0	0.0	0.0
24^{th} hr		0.0	0.0	0.0	0.0
SETTLING VOLUME	(ml)				
MOISTURE RETENTION	(percent)				
1/10 bar					
1/3 bar					
15 bar		7.3	3.7	4.6	2.1
SOIL REACTION-pH					
Paste					
1:5 H_2O		9.5	9.0	9.7	9.7
1:2 0.01 M $CaCl_2$		7.4	7.4	7.5	7.5
ORGANIC CARBON	(percent)				
AVAILABLE PHOSPHORUS	(ppm)				
$CaCO_3$ EQUIVALENT	(percent)				
GYPSUM REQUIREMENT	(me/100g)				
SATURATION EXTRACT					
Saturation Percentage		27.2	22.4	20.9	24.9
EC_e @ 25°C	(mmhos/cm)	3.1	6.0	3.4	3.4
$Ca^{++} + Mg^{++}$	(me/l)	17.4	18.0	4.8	5.2
Mg^{++}	(me/l)				
Na^{+}	(me/l)	30.8	42.0	29.2	27.2
K^{+}	(me/l)				
CO_3^{-}	(me/l)				
HCO_3^{-}	(me/l)				
Cl^{-}	(me/l)				
SO_4^{-}	(me/l)				
NO_3^{-}	(me/l)				
SAR		10.4	14.0	18.8	16.9
Na	(me/100g)				
Ca+Mg	(me/100g)				
1:5 EXTRACT					
EC_5 @ 25°C	(mmhos/cm)	.46	.64	.38	.42
Ca+Mg	(me/l)				
EXCHANGEABLE SODIUM	(percent)	36.2	35.7	38.8	36.2
ACIDITY					
IN KCl exchange acidity					
Total	(me/100g)				
Al^{+++}	(me/100g)				
CATION EXCHANGE CAPACITY	(me/100g)	9.4	7.0	7.2	8.0
NaOAc@pH 8.2					
BORON	(mg/l)				

GPO 833-788

Table Q-13 (cont.)

7-2006A (6-76)
Bureau of Reclamation

U.S BUREAU OF RECLAMATION

POINT SITE LAND CHARACTERIZATION

(WITH DETERMINATIONS)

Study Area: Kimbeto | Relief: Nearly level | Stoniness: None | Parent Material: Eolian and alluvial

Location. Sec. 16 Twp. 22N Range 10W | Elevation: 5980 | | Soil Series: Doak - Negeesi Association

2,500' S, 50' E, NW Corner, Profile 80 | Slope: Aspect: | Drainage: | Soil Classification 1 y / 1,2,7

Climate Arid | Vegetation | Ground Water: None |

Land Use: Rangeland | Erosion: | Land Form: Mesa | Profile Description By R.C. Moore Date 10/76

LAB NO.	DEPTH (Cm.)	PROFILE DESCRIPTION
245	0-45	Loam, dry, 10 YR 5/4, yellowish brown, moderate granular, slightly hard, very slightly plastic and nonsticky
246	45-90	Sandy loam, dry, 10 YR 7/3, very pale brown, moderate granular, slightly hard, nonsticky and nonplastic
247	120-150	Sand, dry, 2.5 Y 8/4, pale yellow, weak single grain, slightly hard, nonsticky and nonplastic
248	150-240	Fine sand, dry, 10 YR 6/3, pale brown, weak single grain, slightly loose, nonsticky and nonplastic
249	250-300	Fine sand, dry, 2.5 Y 7/4, pale yellow, weak single grain, slightly loose, nonsticky and nonplastic

LABORATORY DESCRIPTION						
DETERMINATION		DATA				
LABORATORY NUMBER		245	246	247	248	249
DEPTH	(cm)	0-45	45-90	120-150	150-240	240-300
PARTICLE SIZE ANALYSIS	(percent)					
Very Coarse Sand	(2.0-1.0mm)					
Coarse Sand	(1.0-0.5mm)					
Medium Sand	(0.5-0.25mm)					
Fine Sand	(0.25-0.10mm)					
Very Fine Sand	(0.10-0.05mm)					
Total Sand	(2.0-0.05mm)	66.0	64.8	89.6	91.2	91.2
Silt	(0.05-0.002mm)	20.0	22.2	3.2	4.8	4.6
Clay	(<0.002 mm)	14.0	13.0	7.2	4.0	4.2
TEXTURAL CLASS (LAB)		SL	SL	S	S	S
BULK DENSITY	(g/cm^3)					
HYDRAULIC CONDUCTIVITY	(cm/hr)					
6th hr		.72	.20	10.0	9.6	7.0
24th hr		.88	.22	3.0	2.3	1.4
SETTLING VOLUME	(ml)	18	17	16	17	16
MOISTURE RETENTION	(percent)					
1/10 bar						
1/3 bar						
15 bar		7.2	7.6	2.8	2.7	3.1
SOIL REACTION-pH						
Paste						
1:5 H_2O		8.1	8.9	9.1	8.9	9.1
1:2 0.01 M $CaCl_2$		5.9	6.2	6.6	6.7	6.8
ORGANIC CARBON	(percent)					
AVAILABLE PHOSPHORUS	(ppm)					
$CaCO_3$ EQUIVALENT	(percent)					
GYPSUM REQUIREMENT	(me/100g)					
SATURATION EXTRACT						
Saturation Percentage		26.1	26.0	17.5	20.7	22.3
EC_e @ 25°C	(mmhos/cm)	.43	.53	3.0	3.6	.88
$Ca^{++} + Mg^{++}$	(me/l)	3.1	1.6	10.2	22.6	1.8
Mg^{++}	(me/l)					
Na^{+}	(me/l)	17.0	47.0	21.0	20.0	6.6
K^{+}	(me/l)					
CO_3^{-}	(me/l)					
HCO_3^{-}	(me/l)					
Cl^{-}	(me/l)					
SO_4^{-}	(me/l)					
NO_3^{-}	(me/l)					
SAR		1.4	5.3	9.3	6.0	7.0
Na	(me/100g)					
Ca+Mg	(me/100g)					
1:5 EXTRACT						
EC_5 @ 25°C	(mmhos/cm)	.07	.14	.22	.22	.12
Ca+Mg	(me/l)					
EXCHANGEABLE SODIUM	(percent)	1.8	9.5	13.5	14.3	6.7
ACIDITY						
IN KCl exchange acidity						
Total	(me/100g)					
Al^{+++}	(me/100g)					
CATION EXCHANGE CAPACITY	(me/100g)	13.2	14.8	10.4	4.0	7.0
NaOAc@pH 8.2						
BORON	(mg/l)					

GPO 886-766

Table Q-14

Form 7310-12
(January 1972)

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

By R G MOORE | Date 10-76

Location 1950'W, 2050'S, NE COR PROFILE 62 SEC 7, T22N, R10W

Treatment affecting the SSF

DETERMINATION OF EROSION CONDITION CLASS
SOIL SURFACE FACTORS (SSF)

SOIL MOVEMENT*	No visual evidence of movement 0 1 2 3	Some movement of soil particles 4 5	Moderate movement of soil is visible and recent. Slight terracing generally less than 1" in height. 6 7 8	Occurs with each event. Soil and debris deposited against minor obstructions. 9 10 11	Subsoil exposed over much of area, may have embryonic dunes and wind scoured depressions [12] 13 14
SURFACE LITTER*	Accumulating in place 0 1 2 3	May show slight movement 4 5 6	Moderate movement is apparent, deposited against obstacles 7 8	Extreme movement apparent, large and numerous deposits against obstacles 9 10 11	Very little remaining *(use care on low productive sites)* 12 13 14
SURFACE ROCK*	If present, surface rock or fragments are evenly distributed 0 1 2	If present, surface rock or fragments have a spotty distribution created by surface water flow 3 4 5	If present, surface rock or fragments have a poorly developed distribution pattern 6 7 8	If present, surface rock or fragments exhibit some movement and accumulation of smaller fragments behind obstacles 9 10 11	If present, surface rock or fragments are dissected by rills and gullies or are already washed away 12 13 14
PEDESTALLING*	No visual evidence of pedestalling 0 1 2 3	Slight pedestalling, in flow patterns 4 5 6	Small rock and plant pedestals occurring in flow patterns 7 8 9	Rocks and plants on pedestals generally evident, plant roots exposed [10] 11	Most rocks and plants pedestalled and roots exposed 12 13 14
RILLS	No visual evidence of rills 0 1 2 3	Some rills in evidence but less than ½" deep at infrequent intervals over 10' 4 5 6	Rills ½" to 6" deep occur in exposed places at approximately 10' intervals 7 8 9	Rills ½" to 6" deep occur in exposed area at intervals of 5 to 10' 10 11 12	May be present at 3" to 6" deep at intervals less than 5' [13] 14
FLOW PATTERNS*	No visual evidence of flow patterns 0 1 2 3	Deposition of particles may be in evidence 4 5 6	Well defined with intermittent deposits 7 8 9	Flow patterns contain silt and sand deposits and alluvial fans 10 11 12	Flow patterns are numerous and readily noticeable. May have large barren fan deposits. 13 14 15
GULLIES	May be present in stable condition. Vegetation on channel bed and side slopes 0 1 2 3	A few gullies in evidence which show little bed or slope erosion. Some vegetation is present on slopes. 4 5 6	Gullies are well developed with active erosion along less than 10% of their length 7 8 9	Gullies are numerous and well developed with active erosion along 10 to 50% of their lengths or a few well developed gullies with active erosion along more than 50% of their length 10 11 12	Sharply incised gullies cover most of the area and over 50 % are actively eroding 13 14 15

SITUATION	TOTAL			
		35 ÷ 42 X 100 = 83		

Erosion Condition Classes: Stable 0–20; Slight 21–40; Moderate 41–60; Critical 61–80; Severe 81–100

(Instructions on reverse)

96-Q

Table Q-14 (cont.)
EXAMPLES

ITEM	EXAMPLE ONE			EXAMPLE TWO**			EXAMPLE THREE***		
	POTENTIALLY PRESENT	IDENTIFIED FACTORS	POSSIBLE FACTOR	POTENTIALLY PRESENT	IDENTIFIED FACTORS	POSSIBLE FACTOR	POTENTIALLY PRESENT	IDENTIFIED FACTORS	POSSIBLE FACTOR
Soil Movement	Yes	8	14	Yes	8	14	Yes	8	14
Surface Litter	Yes	9	14	Yes	9	14	Yes	9	14
Surface Rock	Yes	7	14	No	–	– –	No	–	– –
Pedestalling	Yes	10	14	Yes	10	14	Yes	10	14
Rills	Yes	8	14	Yes	8	14	No	–	– –
Flow Patterns	Yes	10	15	Yes	10	15	Yes	10	15
Gullies	Yes	6	15	No	–	– –	No	–	– –
TOTAL		58	100		45	71		37	57
Total SSF		$\frac{58}{100} \times 100 = 58$			$\frac{45}{71} \times 100 = 63$			$\frac{37}{57} \times 100 = 65$	

GENERAL INSTRUCTIONS

District prepares one (1) copy and files in district with particular study under consideration.

Do *not* include items in computations which are not potentially present.

Identify numerical factor that most nearly describes the conditions observed by circling the factor given for each logical item.

**Wind and water are considered eroding agents when evaluating item*
***A soil with no rocks in its profile and no probability of gullying*
****A pumice soil area where no water erosion occurs*

SPECIFIC INSTRUCTIONS

Total all factors at bottom of page. Divide total identified factors by total possible factors for items considered and multiply by 100 in order to compute the SSF.

Situation – Describe situations being evaluated such as present, geologic, with mechanical treatment in effect for 10 years, under a 5 pasture livestock management system for last 8 years, etc.

Total – Total computed SSF.

☆ U. S. GOVERNMENT PRINTING OFFICE 1972--780-678/117 REGION NO. 8

Form 7310–12
(May 1973)

Table Q-14 (cont.)
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

By RG MOORE | Date 10-76

Location 2000' W, 1650' S NE COR. SEC 15, T22N, R10W PROFILE

Treatment affecting the SSF

DETERMINATION OF EROSION CONDITION CLASS

SOIL SURFACE FACTORS (SSF)

SOIL MOVEMENT*	No visual evidence of movement				Some movement of soil particles		Moderate movement of soil is visible and recent. Slight terracing generally less than 1" in height.			Occurs with each event. Soil and debris deposited against minor obstructions.			Subsoil exposed over much of area, may have embryonic dunes and wind scoured depressions		
	0	1	2	3	4	5	[6]	7	8	9	10	11	12	13	14
SURFACE LITTER*	Accumulating in place				May show slight movement		Moderate movement is apparent, deposited against obstacles			Extreme movement apparent, large and numerous deposits against obstacles			Very little remaining *(use care on low productive sites)*		
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
SURFACE ROCK*	If present, the distribution of fragments show no movement caused by wind or water				If present, coarse fragments have a truncated appearance or spotty distribution caused by wind or water			If present, fragments have a poorly developed distribution pattern caused by wind or water			If present, surface rock or fragments exhibit same movement and accumulation of smaller fragments behind obstacles			If present, surface rock or fragments are dissected by rills and gullies or are already washed away	
	0	1	2		3	4	5	6	7	8	9	10	11	12	13	14
PEDESTALLING*	No visual evidence of pedestalling				Slight pedestalling, in flow patterns			Small rock and plant pedestals occurring in flow patterns			Rocks and plants on pedestals generally evident, plant roots exposed			Most rocks and plants pedestalled and roots exposed	
	0	1	2	3	[4]	5	6	7	8	9	10	11		12	13	14
FLOW PATTERNS*	No visual evidence of flow patterns				Deposition of particles may be in evidence			Well defined, small, and few with intermittent deposits			Flow patterns contain silt and sand deposits and alluvial fans			Flow patterns are numerous and readily noticeable. May have large barren fan deposits.	
	0	1	[2]	3	4	5	6	7	8	9	10	11	12	13	14	15
RILLS	No visual evidence of rills				Some rills in evidence at infrequent intervals over 10'			Rills ½" to 6" deep occur in exposed places at approximately 10' intervals			Rills ½" to 6" deep occur in exposed area at intervals of 5 to 10'			May be present at 3" to 6" deep at intervals less than 5'	
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	
GULLIES	May be present in stable condition. Vegetation on channel bed and side slopes				A few gullies in evidence which show little bed or slope erosion. Some vegetation is present on slopes.			Gullies are well developed with active erosion along less than 10% of their length. Some vegetation may be present.			Gullies are numerous and well developed with active erosion along 10 to 50% of their lengths or a few well developed gullies with active erosion along more than 50% of their length			Sharply incised gullies cover most of the area and over 50% are actively eroding	
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15

SITUATION	TOTAL		
		12 ÷ 43 X 100 =	28

Erosion Condition Classes: Stable 0–20; Slight 21–40; Moderate 41–60; Critical 61–80; Severe 81–100

(Instructions on reverse)

86-D

Form 7310–12
(May 1973)

Table Q-14 (cont.)
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

By R G MOORE | Date 10-76

Location 2150'S, 1900'W NE COR.
PROFILE 29 SEC. 27, T22N, R10W

Treatment affecting the SSF

DETERMINATION OF EROSION CONDITION CLASS

SOIL SURFACE FACTORS (SSF)

SOIL MOVEMENT*	No visual evidence of movement 0 1 2 3	Some movement of soil particles 4 [5]	Moderate movement of soil is visible and recent. Slight terracing generally less than 1" in height. 6 7 8	Occurs with each event. Soil and debris deposited against minor obstructions. 9 10 11	Subsoil exposed over much of area, may have embryonic dunes and wind scoured depressions 12 13 14
SURFACE LITTER*	Accumulating in place 0 1 2 3	May show slight movement 4 5 6	Moderate movement is apparent, deposited against obstacles 7 8	Extreme movement apparent, large and numerous deposits against obstacles 9 10 11	Very little remaining *(use care on low productive sites)* 12 13 14
SURFACE ROCK*	If present, the distribution of fragments show no movement caused by wind or water 0 1 2	If present, coarse fragments have a truncated appearance or spotty distribution caused by wind or water 3 4 5	If present, fragments have a poorly developed distribution pattern caused by wind or water 6 7 8	If present, surface rock or fragments exhibit same movement and accumulation of smaller fragments behind obstacles 9 10 11	If present, surface rock or fragments are dissected by rills and gullies or are already washed away 12 13 14
PEDESTALLING*	No visual evidence of pedestalling 0 1 2 3	Slight pedestalling, in flow patterns [4] 5 6	Small rock and plant pedestals occurring in flow patterns 7 8 9	Rocks and plants on pedestals generally evident, plant roots exposed 10 11	Most rocks and plants pedestalled and roots exposed 12 13 14
FLOW PATTERNS*	No visual evidence of flow patterns 0 1 2 3	Deposition of particles may be in evidence 4 5 6	Well defined, small, and few with intermittent deposits 7 8 9	Flow patterns contain silt and sand deposits and alluvial fans 10 11 12	Flow patterns are numerous and readily noticeable. May have large barren fan deposits. 13 14 15
RILLS	No visual evidence of rills 0 1 2 3	Some rills in evidence at infrequent intervals over 10' 4 5 6	Rills ½" to 6" deep occur in exposed places at approximately 10' intervals 7 8 9	Rills ½' to 6" deep occur in exposed area at intervals of 5 to 10' 10 11 12	May be present at 3" to 6" deep at intervals less than 5' 13 14
GULLIES	May be present in stable condition. Vegetation on channel bed and side slopes 0 1 2 3	A few gullies in evidence which show little bed or slope erosion. Some vegetation is present on slopes. 4 5 6	Gullies are well developed with active erosion along less than 10% of their length. Some vegetation may be present. 7 8 9	Gullies are numerous and well developed with active erosion along 10 to 50% of their lengths or a few well developed gullies with active erosion along more than 50% of their length 10 11 12	Sharply incised gullies cover most of the area and over 50% are actively eroding 13 14 15

SITUATION	TOTAL				
		9 ÷ 28 x 100 = 32			

Erosion Condition Classes: Stable 0–20; Slight 21–40; Moderate 41–60; Critical 61–80; Severe 81–100

(Instructions on reverse)

66-D

Form 7310–12
(May 1973)

Table 0-14 (cont.)

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

By: RG MOORE | Date: 10-76

Location: 450'S, 2500'E, NW COR. PROFILE 38 SEC. 24, T22N, R10W

Treatment affecting the SSF

DETERMINATION OF EROSION CONDITION CLASS

SOIL SURFACE FACTORS (SSF)

SOIL MOVEMENT *	No visual evidence of movement 0 1 2 3	Some movement of soil particles 4 5	Moderate movement of soil is visible and recent. Slight terracing generally less than 1" in height. 6 7 8	Occurs with each event. Soil and debris deposited against minor obstructions. 9 [10] 11	Subsoil exposed over much of area, may have embryonic dunes and wind scoured depressions 12 13 14
SURFACE LITTER *	Accumulating in place 0 1 2 3	May show slight movement 4 5 6	Moderate movement is apparent, deposited against obstacles 7 8	Extreme movement apparent, large and numerous deposits against obstacles 9 10 11	Very little remaining *(use care on low productive sites)* 12 13 14
SURFACE ROCK *	If present, the distribution of fragments show no movement caused by wind or water 0 1 2	If present, coarse fragments have a truncated appearance or spotty distribution caused by wind or water 3 4 5	If present, fragments have a poorly developed distribution pattern caused by wind or water 6 7 8	If present, surface rock or fragments exhibit same movement and accumulation of smaller fragments behind obstacles 9 10 11	If present, surface rock or fragments are dissected by rills and gullies or are already washed away 12 13 14
PEDESTALLING *	No visual evidence of pedestalling 0 1 2 3	Slight pedestalling, in flow patterns 4 5 6	Small rock and plant pedestals occurring in flow patterns 7 8 9	Rocks and plants on pedestals generally evident, plant roots exposed 10 [11]	Most rocks and plants pedestalled and roots exposed 12 13 14
FLOW PATTERNS *	No visual evidence of flow patterns 0 1 2 3	Deposition of particles may be in evidence 4 5 6	Well defined, small, and few with intermittent deposits 7 8 9	Flow patterns contain silt and sand deposits and alluvial fans 10 11 12	Flow patterns are numerous and readily noticeable. May have large barren fan deposits. 13 14 15
RILLS	No visual evidence of rills 0 1 2 3	Some rills in evidence at infrequent intervals over 10' 4 5 6	Rills ½" to 6" deep occur in exposed places at approximately 10' intervals 7 8 9	Rills ½" to 6" deep occur in exposed area at intervals of 5 to 10' 10 11 12	May be present at 3" to 6" deep at intervals less than 5' 13 14
GULLIES	May be present in stable condition. Vegetation on channel bed and side slopes 0 1 2 3	A few gullies in evidence which show little bed or slope erosion. Some vegetation is present on slopes. 4 5 6	Gullies are well developed with active erosion along less than 10% of their length. Some vegetation may be present. 7 8 9	Gullies are numerous and well developed with active erosion along 10 to 50% of their lengths or a few well developed gullies with active erosion along more than 50% of their length 10 11 12	Sharply incised gullies cover most of the area and over 50% are actively eroding 13 14 15

SITUATION	TOTAL				
		21 ÷ 28 x 100 =	75		

Erosion Condition Classes: Stable 0–20; Slight 21–40; Moderate 41–60; Critical 61–80; Severe 81–100

(Instructions on reverse)

Q-100

Table Q-14 (cont.)

Form 7310-12
(January 1972)

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

By RG MOORE | Date 10-76

Location 1550'W, 1900'N SE COR.
PROFILE 58 SEC. 16, T22N, R10W

Treatment affecting the SSF

DETERMINATION OF EROSION CONDITION CLASS
SOIL SURFACE FACTORS (SSF)

SOIL MOVEMENT*	No visual evidence of movement 0 1 2 3	Some movement of soil particles 4 5	Moderate movement of soil is visible and recent. Slight terracing generally less than 1" in height. 6 7 8	Occurs with each event. Soil and debris deposited against minor obstructions. (9) 10 11	Subsoil exposed over much of area, may have embryonic dunes and wind scoured depressions 12 13 14
SURFACE LITTER*	Accumulating in place 0 1 2 3	May show slight movement 4 5 6	Moderate movement is apparent, deposited against obstacles 7 8	Extreme movement apparent, large and numerous deposits against obstacles 9 10 11	Very little remaining *(use care on low productive sites)* 12 13 14
SURFACE ROCK*	If present, surface rock or fragments are evenly distributed 0 1 2	If present, surface rock or fragments have a spotty distribution created by surface water flow 3 4 5	If present, surface rock or fragments have a poorly developed distribution pattern 6 7 8	If present, surface rock or fragments exhibit some movement and accumulation of smaller fragments behind obstacles 9 10 11	If present, surface rock or fragments are dissected by rills and gullies or are already washed away 12 13 14
PEDESTALLING*	No visual evidence of pedestalling 0 1 2 3	Slight pedestalling, in flow patterns 4 5 6	Small rock and plant pedestals occurring in flow patterns 7 8 (9)	Rocks and plants on pedestals generally evident, plant roots exposed 10 11	Most rocks and plants pedestalled and roots exposed 12 13 14
RILLS	No visual evidence of rills 0 1 2 3	Some rills in evidence but less than ½" deep at infrequent intervals over 10' 4 5 6	Rills ½" to 6" deep occur in exposed places at approximately 10' intervals 7 8 9	Rills ½" to 6" deep occur in exposed area at intervals of 5 to 10' 10 (11) 12	May be present at 3" to 6" deep at intervals less than 5' 13 14
FLOW PATTERNS*	No visual evidence of flow patterns 0 1 2 3	Deposition of particles may be in evidence 4 5 6	Well defined with intermittent deposits 7 8 9	Flow patterns contain silt and sand deposits and alluvial fans 10 11 12	Flow patterns are numerous and readily noticeable. May have large barren fan deposits. 13 14 15
GULLIES	May be present in stable condition. Vegetation on channel bed and side slopes 0 1 2 3	A few gullies in evidence which show little bed or slope erosion. Some vegetation is present on slopes. 4 5 6	Gullies are well developed with active erosion along less than 10% of their length 7 8 9	Gullies are numerous and well developed with active erosion along 10 to 50% of their lengths or a few well developed gullies with active erosion along more than 50% of their length 10 11 12	Sharply incised gullies cover most of the area and over 50 % are actively eroding 13 14 15

SITUATION	TOTAL			
		29 ÷ 42 X 100 =	69	

Erosion Condition Classes: Stable 0–20; Slight 21–40; Moderate 41–60; Critical 61–80; Severe 81–100

(Instructions on reverse)

Table Q-14 (cont.)

Form 7310–12
(January 1972)

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

By RG MOORE | Date 10-76

Location 2500'S, 50'E NWCOR SEC. 16 T22N, R10W
PROFILE 80

Treatment affecting the SSF

DETERMINATION OF EROSION CONDITION CLASS
SOIL SURFACE FACTORS (SSF)

SOIL MOVEMENT*	No visual evidence of movement 0 1 2 3	Some movement of soil particles 4 [5]	Moderate movement of soil is visible and recent. Slight terracing generally less than 1" in height. 6 7 8	Occurs with each event. Soil and debris deposited against minor obstructions. 9 10 11	Subsoil exposed over much of area, may have embryonic dunes and wind scoured depressions 12 13 14
SURFACE LITTER*	Accumulating in place 0 1 2 3	May show slight movement 4 5 6	Moderate movement is apparent, deposited against obstacles 7 8	Extreme movement apparent, large and numerous deposits against obstacles 9 10 11	Very little remaining *(use care on low productive sites)* 12 13 14
SURFACE ROCK*	If present, surface rock or fragments are evenly distributed 0 1 2	If present, surface rock or fragments have a spotty distribution created by surface water flow 3 4 5	If present, surface rock or fragments have a poorly developed distribution pattern 6 7 8	If present, surface rock or fragments exhibit some movement and accumulation of smaller fragments behind obstacles 9 10 11	If present, surface rock or fragments are dissected by rills and gullies or are already washed away 12 13 14
PEDESTALLING*	No visual evidence of pedestalling 0 1 2 3	Slight pedestalling, in flow patterns [4] 5 6	Small rock and plant pedestals occurring in flow patterns 7 8 9	Rocks and plants on pedestals generally evident, plant roots exposed 10 11	Most rocks and plants pedestalled and roots exposed 12 13 14
RILLS	No visual evidence of rills 0 1 2 3	Some rills in evidence but less than ½" deep at infrequent intervals over 10' 4 5 6	Rills ½" to 6" deep occur in exposed places at approximately 10' intervals 7 8 9	Rills ½" to 6" deep occur in exposed area at intervals of 5 to 10' 10 11 12	May be present at 3" to 6" deep at intervals less than 5' 13 14
FLOW PATTERNS*	No visual evidence of flow patterns 0 1 2 3	Deposition of particles may be in evidence 4 5 6	Well defined with intermittent deposits 7 8 9	Flow patterns contain silt and sand deposits and alluvial fans 10 11 12	Flow patterns are numerous and readily noticeable. May have large barren fan deposits. 13 14 15
GULLIES	May be present in stable condition. Vegetation on channel bed and side slopes 0 1 2 3	A few gullies in evidence which show little bed or slope erosion. Some vegetation is present on slopes. 4 5 6	Gullies are well developed with active erosion along less than 10% of their length 7 8 9	Gullies are numerous and well developed with active erosion along 10 to 50% of their lengths or a few well developed gullies with active erosion along more than 50% of their length 10 11 12	Sharply incised gullies cover most of the area and over 50 % are actively eroding 13 14 15

SITUATION	TOTAL			
		9 ÷ 28 x 100 =	32	

Erosion Condition Classes: Stable 0–20; Slight 21–40; Moderate 41–60; Critical 61–80; Severe 81–100

(Instructions on reverse)

U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

Table Q-15

VEGETATION-SOIL DESCRIPTION

1. State	2. District	3. Planning Unit	4. Vegetation–Soil Unit	5. Soil Map Symbol	6. Surname	7. Date
NM	--	--	---------- / --------	7002	RG MOORE	10 mo 76 yr

8. Area	9. County	10. Location	11. Photo No.	12. Writeup No.	13. File No.	14. Parent Rock
--	SAN JUAN	Sec. 7, T. 22N, R. 10W	----------	----	------	Alluvium & RESIDUAL

15. Formation Name	16. Surface Conditions (percent)	17. Land Conditions	18. Landform
FRUITLAND	Stone -- Rock --	Alkaline Saline Water table NONE	BADLAND

19. Slope (percent)	20. Aspect	21. Elevation	22. Present Erosion	23. Hydrologic Group
0-3 ☒ Single ☐ Complex	W-SW	6200	SEVERE Type WIND & WATER SSF 83 Class -	-

24. Precipitation (in)	25. Temperature	26. Frost-free	27. Drainage Class	28. Infiltration	29. Percolation	30. ERD	31. AWC
5-8 TOTAL - 1st , 2nd , 3rd , 4th	53 Air 55 Soil	Days 146 > 28°	POOR	FAIR	POOR	-- in	--.- in

32. HORIZON	33. THICKNESS	34. COLOR DRY / MOIST — MATRIX	34. COLOR DRY / MOIST — MOTTLING	35. TEXTURE	36. STRUCTURE	37. CONSISTENCY DRY MOIST	38. CLAY FILMS	39. ROOTS	40. STONES % VOL.	41. REACTION (pH)	42. BOUNDARY
A1	0-24	5Y 5/3 D		LFS	wk granular	sli hard N sti & N pls				9.4	CS
C 123	24-60	5Y 7/2 D		L	WK SBK	v hard v sli sti & v sli pls				9.3	CS
C 4	60-102	5Y 6/3 D		S	wk granular	sli loose N sti & N pls				9.9	CS
Cr 1	102-120	5Y 7/4 D		Sh	Mod MASS	v hard sti & pls				10.0	

MASTER Site FOR MAPPING UNIT 7002, a SANDY Loam phase of STUMBLE SERIES
Profile 62 1950'W 2050's NE COR Sec 7 T22N R 10W

U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

Table 0-15 (cont.)

VEGETATION–SOIL DESCRIPTION

1. State	2. District	3. Planning Unit	4. Vegetation–Soil Unit	5. Soil Map Symbol	6. Surname	7. Date
NM	FARM	--	---------- / --------	7010	R G Moore	10 mo 76 yr

8. Area	9. County	10. Location	11. Photo No.	12. Writeup No.	13. File No.	14. Parent Rock
--	San Juan	Sec. 25, T. 22N, R. 10W	----------	----	------	Alluvium

15. Formation Name	16. Surface Conditions (percent)	17. Land Conditions	18. Landform
FRUITLAND	Stone -- Rock --	Alkaline Saline Water table NONE	VALLEY

19. Slope (percent)	20. Aspect	21. Elevation	22. Present Erosion	23. Hydrologic Group
0-3 ☒ Single ☐ Complex	SW	5980	Type WIND SSF 28 Class – SLIGHT	–

24. Precipitation (in)	25. Temperature	26. Frost-free	27. Drainage Class	28. Infiltration	29. Percolation	30. ERD	31. AWC
5-8 Total 1st, 2nd, 3rd, 4th	53 Air 55 Soil	Days 146 > 28°	Poor	Fair		-- in	--.- in

32. HORIZON	33. THICKNESS	34. COLOR DRY MOIST — MATRIX	34. COLOR DRY MOIST — MOTTLING	35. TEXTURE	36. STRUCTURE	37. CONSISTENCY DRY MOIST	38. CLAY FILMS	39. ROOTS	40. STONES % VOL.	41. REACTION (pH)	42. BOUNDARY
A1	0-12	2.5Y 4/4 D		FS	SG	loose Nsti & Npls				7.9	CS
C1	12-36	2.5Y 7/2 D		FS	SG	sli hard Nsti & Npls				9.5	GS
C2	36-66	10YR 4/4 D		LFS	SG	V sli hard Nsti & Npls				9.5	DS
C3	66-94	2.5Y 5/2 D		CL	Mod granular	sli soft sli sti & sli pls				9.2	AS
Cr1	94-108	5Y 7/1 D		SS	Mod Mass	sli hard Nsti & Npls					

MASTER Site for MApping Unit 7010 Stumble series Profile 15
2000'W, 1650'S NE COR Sec25, T22N, R10W

U S. DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

Table Q-15 (cont.)

VEGETATION–SOIL DESCRIPTION

1. State	2. District	3. Planning Unit	4. Vegetation–Soil Unit	5. Soil Map Symbol	6. Surname	7. Date
NM	FARM	--	---------- / --------	7004	RG MOORE	10 mo 76 yr

8. Area	9. County	10. Location	11. Photo No.	12. Writeup No.	13. File No.	14. Parent Rock
--	SAN JUAN	Sec. 27, T. 22 N., R. 10 W	----------	----	------	Alluvium

15. Formation Name	16. Surface Conditions (percent)	17. Land Conditions	18. Landform
FRUITLAND	Stone -- Rock --	Alkaline Saline Water table NONE	MESA

19. Slope (percent)	20. Aspect	21. Elevation	22. Present Erosion	23. Hydrologic Group
0-3 ☒ Single ☐ Complex	W	5980	SLIGHT Type WIND SSF 32 Class –	–

24. Precipitation (in)	25. Temperature	26. Frost-free	27. Drainage Class	28. Infiltration	29. Percolation	30. ERD	31. AWC
5-8 TOTAL 1st , 2nd , 3rd , 4th	53 Air 55 Soil	Days 146 > 28°	well drained	Good	Good	-- in	--.-- in

32. HORIZON	33. THICKNESS	34. COLOR DRY MOIST — MATRIX	34. COLOR DRY MOIST — MOTTLING	35. TEXTURE	36. STRUCTURE	37. CONSISTENCY DRY MOIST	38. CLAY FILMS	39. ROOTS	40. STONES % VOL.	41. REACTION (pH)	42. BOUNDARY
A&B	0-12	10YR 5/6 D		L	Mod gran	Sli soft NSti & NPls				6.9	CS
C1	12-36	10YR 5/4 D		SL	mod gran	V sli hard NSti & NPls				8.4	CS
C2	36-82	10YR 6/4 D		LFS	weak SG	V sli hard NSti & NPls				9.0	GS
C3	82-120	10YR 8/3 D		S	Mod SG	sli loose NSti & NPls				9.2	

MASTER SITE FOR MAPPING UNIT 7004 SHIPROCK SERIES Profile 29
2150'S, 1900'W, NE COR SEC 27, T22N, R 10W

Q-105

U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

Table Q-15 (cont.)

VEGETATION–SOIL DESCRIPTION

1. State	2. District	3. Planning Unit	4. Vegetation–Soil Unit	5. Soil Map Symbol	6. Surname	7. Date
NM	FARM	--	---------- / -------	7015	RG MOORE -------	10 mo 76 yr

8. Area	9. County	10. Location	11. Photo No.	12. Writeup No.	13. File No.	14. Parent Rock
--	San Juan	Sec. 24, T. 22N, R. 10W	----------	----	------	Alluvium

15. Formation Name	16. Surface Conditions (percent)	17. Land Conditions	18. Landform
FRUITLAND	Stone -- Rock --	Alkaline Saline Water table NONE	Hummocky

19. Slope (percent)	20. Aspect	21. Elevation	22. Present Erosion	23. Hydrologic Group
0-3 ☐ Single ☒ Complex	SW	5980	CRITICAL Type WIND SSF 75 Class -	-

24. Precipitation (in)	25. Temperature	26. Frost-free	27. Drainage Class	28. Infiltration	29. Percolation	30. ERD	31. AWC
5-8 TOTAL 1st , 2nd , 3rd , 4th	53 Air 55 Soil	Days 146 > 28°	Good	Good	Good	-- in	--.- in

32. HORIZON	33. THICKNESS	34. COLOR DRY MOIST — MATRIX	34. COLOR DRY MOIST — MOTTLING	35. TEXTURE	36. STRUCTURE	37. CONSISTENCY DRY MOIST	38. CLAY FILMS	39. ROOTS	40. STONES % VOL.	41. REACTION (pH)	42. BOUNDARY
AC	0-24	10YR 6/3 D		FS	SG	sli loose N sti & NP/s				8.5	CS
C1&2	24-60	10YR 6/3 D		FS	ST SG	sli hard N sti & NP/s				9.8	

MASTER SITE FOR MAPPING UNIT 7015 SHEPPARD SERIES PROFILE 30
450'S, 2500'E, NW COR SEC 24, T22N, R10W

106

U.S DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

Table 0-15 (cont.)

VEGETATION–SOIL DESCRIPTION

1. State	2. District	3. Planning Unit	4. Vegetation–Soil Unit	5. Soil Map Symbol	6. Surname	7. Date
NM	FARM	__	----------/--------	7013	RG MOORE	10 mo 76 yr

8. Area	9. County	10. Location	11. Photo No.	12. Writeup No.	13. File No.	14. Parent Rock
__	San Juan	Sec. ---, T. ---, R. ---	----------	----	------	ALLUVIUM

15. Formation Name	16. Surface Conditions (percent)	17. Land Conditions	18. Landform
FRUITLAND	Stone -- Rock --	Alkaline Saline Water table NONE	VALLEY

19. Slope (percent)	20. Aspect	21. Elevation	22. Present Erosion	23. Hydrologic Group
0-5 [X] Single [ ] Complex	S	5960	Type WIND & WATER SSF 69 Class CRITICAL	-

24. Precipitation (in)	25. Temperature	26. Frost-free	27. Drainage Class	28. Infiltration	29. Percolation	30. ERD	31. AWC
5-8 TOTAL 1st , 2nd , 3rd , 4th	53 Air 55 Soil	Days 146 > 28°	POOR	POOR	POOR	-- in	--.- in

32. HORIZON	33. THICKNESS	34. COLOR DRY MOIST — MATRIX	34. COLOR DRY MOIST — MOTTLING	35. TEXTURE	36. STRUCTURE	37. CONSISTENCY DRY MOIST	38. CLAY FILMS	39. ROOTS	40. STONES % VOL.	41. REACTION (pH)	42. BOUNDARY
A11&12	0-6	5Y 6/3 D		CL	WK SBK	sli hard slist & slpls				9.5	AS
C1	6-48	5Y 7/2 D		LFS	Mod gran	sli hard Nsti & Npls				9.0	CS
C2	48-84	5Y 7/3 D		FS	mod gran	v hard Nsti & Npls				9.7	CS
C3	84-120	5Y 6/3 D		FSL	mod gran	v hard Nsti & Npls				9.7	

MASTER site for MAPPING UNIT 7013 BLANCOT SERIES PROFILE 58
1550'W, 1900'N, SE COR SEC 16 T22N, R10W

U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

Table Q-15 (cont.)

VEGETATION–SOIL DESCRIPTION

1. State	2. District	3. Planning Unit	4. Vegetation–Soil Unit	5. Soil Map Symbol	6. Surname	7. Date
NM	FARM		----------/--------	7012	RG MOORE	10 mo 76 yr

8. Area	9. County	10. Location	11. Photo No.	12. Writeup No.	13. File No.	14. Parent Rock
--	SAN JUAN	Sec. ---, T. ---, R. ---	----------	----	------	Alluvium

15. Formation Name	16. Surface Conditions (percent)	17. Land Conditions	18. Landform
FRUITLAND	Stone -- Rock --	Alkaline Saline Water table NONE	MESA

19. Slope (percent)	20. Aspect	21. Elevation	22. Present Erosion	23. Hydrologic Group
NEARLY LEVEL ☐ Single ☐ Complex	--	5980	Type WIND SSF 32 Class SLIGHT	-

24. Precipitation (in)	25. Temperature	26. Frost-free	27. Drainage Class	28. Infiltration	29. Percolation	30. ERD	31. AWC
5-8 TOTAL 1st , 2nd , 3rd , 4th	-- Air 53 55 Soil	Days 146 > 28°	GOOD	GOOD	GOOD	-- in	--.- in

32. HORIZON	33. THICKNESS	34. COLOR DRY / MOIST — MATRIX	34. COLOR DRY / MOIST — MOTTLING	35. TEXTURE	36. STRUCTURE	37. CONSISTENCY DRY MOIST	38. CLAY FILMS	39. ROOTS	40. STONES % VOL.	41. REACTION (pH)	42. BOUNDARY
A1&B2	0-18	10YR 5/4 D		L	MOD GRAN	SLI HARD NSTI&VSL.P/S				8.1	CS
C1	18-36	10YR 7/3 D		SL	MOD GRAN	SLI HARD NSTI&NP/S				8.9	CS
C2	48-60	2.5Y 8/4 D		S	WK SG	SLI HARD NSTI&NP/S				9.1	CS
C3	60-96	10YR 6/3 D		FS	WK SG	SLI LOOSE NSTI&NP/S				8.9	CS
C4	96-120	2.5Y 7/4 D		FS	WK SG	SLI LOOSE NSTI&NP/S				9.1	

MASTER SITE FOR MAPPING UNIT 7012 NAGEEZI SERIES PROFILE 80
2500'S, 50'E NW COR., SEC 16, T22N, R10W

SECTION R

SOIL MOISTURE RELATIONSHIPS ASSOCIATED WITH VEGETATION TYPES AND LANDFORMS APPENDIX

SECTION R

SOIL-MOISTURE RELATIONSHIPS ASSOCIATED WITH VEGETATION TYPES AND LANDFORMS APPENDIX

Concepts and Methods for Soil Moisture Relationships Associated with Vegetation Types and Landforms

Concepts

The soil moisture theory employed here is taken from Miller and McQueen (1978). It is based on a graphic model of soil moisture characteristics developed by McQueen and Miller (1974). An outline of the essential concepts and an explanation of the parameters involved are presented here.

According to the model, moisture can be held to the soil in three states: tightly adsorbed, adsorbed, and capillary. The tightly adsorbed moisture is held to the soil by retention forces varying from pF 5 to pF 7 (10^5 to 10^7 g/cm^2). This is also referred to as structural water. On top of this moisture is adsorbed water which is held by forces from pF 0 to pF 5 (10^0 to 10^5 g/cm^2). Capillary forces may hold more moisture on top of the adsorbed water in the range of pF 0 to pF 2.34 (10^0 to $10^{2.34}$ g/cm^2). The forces involved are given in pF (the logarithm of force measured in g/cm^2) because the force increases exponentially with decreasing moisture content (see figure R-1).

The model was developed on the assumption that all significant soil particle surface area is contributed by the platelike surfaces of clays. With its high specific surface, a small percent of clay accounts for a large proportion of the surface area. This assumption leads to a linear relationship between moisture content and molecular layers of water adsorbed to the soil particles. Miller and McQueen (in press), using data from Michurin and Lytayev (1967), have combined this relationship with their moisture retention graph to indicate a universal exponential relationship between the moisture retention force and molecular layers of water adsorbed to the soil (see figure R-1). At a force of pF 2.34 ($10^{2.34}$ g/cm^2) there are always 10 molecular layers adsorbed. In a fine-textured soil, this will amount to a much higher moisture content than in a coarse-textured soil because there will be 10 layers adsorbed to a larger amount of surface. Therefore, the moisture content at a specific retention force varies with the specific surface of the soil, whereas the number of molecular layers is a constant.

The major function of the model is to determine two important parameters, moisture-retention capability (MRC) and adsorption-moisture capability (AMC). MRC is the moisture content at pF 2.34 ($10^{2.34}$ g/cm^2); it is equal to 10 molecular layers of water. AMC is the moisture content at pF 0 (1 g/cm^2); it is equal to 16 molecular layers of water. MRC is analagous to field capacity in application, but its definition is not time dependent. MRC is the limit of moisture content below which gravity is assumed to be insignificant compared to the adsorptive force. AMC is the upper limit of moisture content above which the adsorptive force is considered insignificant compared to gravity. Between MRC and AMC, both forces can be effective.

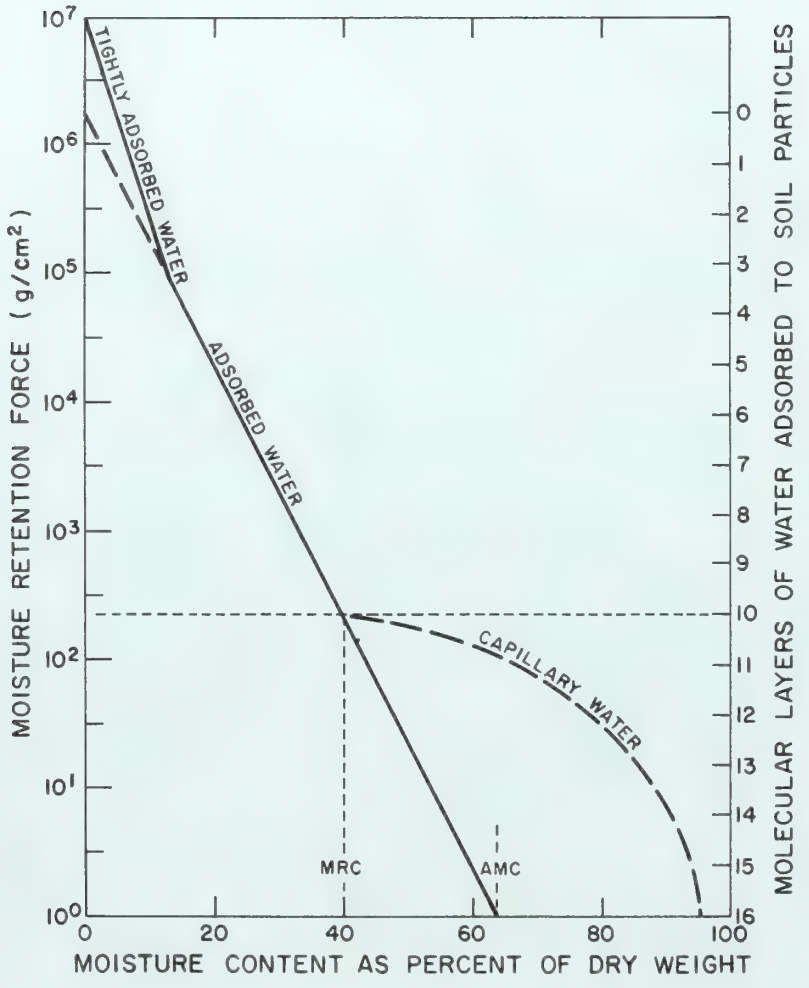


Figure R-1.--A graphic model showing the relationship of moisture-retention force to moisture content for a particular soil.

Extrapolation of the adsorbed water segment of the graph gives an intercept of $10^{6.25}$ g/cm^2 (pF 6.25) at zero moisture content (see figure R-1). The intercept of the tightly adsorbed segment is 10^7 g/cm^2 (pF 7). The moisture retention graph can be constructed for any soil with these known intercepts and one measured soil moisture content and associated stress value within the adsorbed segment. If the stress value is within the pF range 0 to 5 (1 to 10^5 g/cm^2), a line can be drawn from $(0,10^{6.25})$ through the point representing the measured soil moisture and stress. The intercept on the soil moisture axis is the AMC.

If the measured stress is between pF 5 and pF 7 (10^5 to 10^7 g/cm), then this point lies on the tightly adsorbed segment. In order to get the AMC and MRC, first the tightly adsorbed segment must be sketched in from the known intercept $(0,10^7)$ through the measured values of soil moisture and stress down to 10^5 g/cm^2 (pF 5). Now, the adsorbed segment can be sketched in from $(0,10^{6.25})$ through the end point of the tightly adsorbed segment at 10^5 g/cm^2 (pF 5) because this point is common to both segments. AMC is then the soil moisture intercept of the adsorbed segment.

If the measured soil moisture stress is below pF 2.34 ($10^{2.34}$ g/cm^2), then there may be capillary water present in excess of the adsorbed water. If this is the case, using that point to model the soil will skew the adsorbed line, making it less steep and giving higher values for AMC and MRC than are correct.

The third parameter involved in this analysis is the void-moisture capacity (VMC). It is a function solely of bulk density or volume weight (VW) of the soil, assuming that the specific gravity of the soil is 2.65 (see figure R-2). VMC is the water content of the soil, on a dry weight basis, when all of the voids are filled at the existing field volume weight of the soil.

MRC, AMC, VMC, and antecedent moisture are the controlling soil factors in infiltration, drainage (permeability), moisture retention, and moisture available to vegetation. Infiltration is limited by available voids in the surface soil. Available voids can be expressed as (VMC − antecedent moisture) x volume weight. Infiltration is also affected by MRC and AMC. If VMC is less than MRC, then the available voids will fill initially, but the adsorptive force will hold this moisture and thereby block further infiltration. If VMC is greater than MRC but less than AMC, the voids will not be totally blocked, but infiltration will be appreciably slowed.

Drainage (permeability) is treated here in the same manner as infiltration. Each 10 cm depth increment may either block drainage by constriction (VMC less than MRC or AMC) or allow unrestricted drainage (VMC much greater than AMC). The void volume per unit area (cm^3/cm^2 = cm)

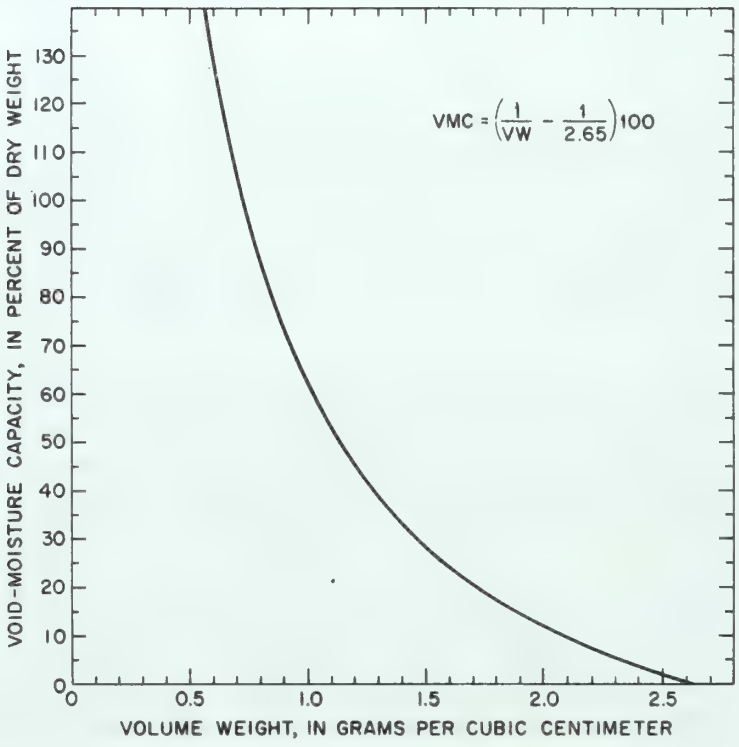


Figure R-2.--Relationship used to determine void-moisture capacity (VMC) of soils from volume weight (VW).

is computed for each increment. This is separated into the voids necessary to fulfill the MRC and the voids in excess of this which are subject to drainage. The total volume is the capacity for initial absorbtion, but the void volume in excess of MRC determines further drainage.

The quantity of water available to vegetation is a function of the vegetation type, the MRC, and amount of evaporation. At the soil surface, evaporative forces can remove moisture to the level of one molecular layer on the soil particles at the surface. Rangeland vegetation, however, can only exert forces sufficient to remove moisture by transpiration down to three, four, or five layers, depending on the species (Miller and McQueen, 1978). The force that the species can exert defines the transpiration limit for that species. Transpiration and evaporation are responsible for depletion of moisture from MRC to the transpiration limit and also of some moisture above the MRC while the profile is draining. Since the model does not predict drainage rates, it cannot be determined how much of the moisture is used by the vegetation while drainage is occurring.

Methods

Soil samples were taken in October 1976 with an orchard-type hand auger in 10 cm (100 mm) increments. The volume of the auger for a 10-cm increment was 203 cc. Each sample was placed in a plastic zip-lock bag and a 5.5 cm diameter Schleicher and Schuell No. 589 white ribbon filter paper treated with a 2 percent pentachlorophenol in alcohol was inserted in the bag as a stress sensor. Then, the bag was tumbled to mix the sample. Each bag was placed in a soil-moisture can which was then sealed with black plastic tape. The samples equilibrated in a constant temperature room at 20°C for at least 1 week. Moisture contents for the soil and the filter papers were measured gravimetrically. Drying time was overnight at 105°to 110°C. Moisture stress was determined from the moisture content of the filter papers (McQueen and Miller, 1968).

Volume weights (VW) were calculated by assuming a specific gravity of 2.65 for all soils. The values of VW for the first and last increment of each profile were computed from the weight of soil in that increment. All other VW values were an average of the values for that increment, the preceding one, and the succeeding one. This was done to compensate for discrepancies between the actual volume of sample obtained for each increment and the volume of the auger. Since some VW measurements were subject to large error caused by surface soil caving in, obviously incorrect values were replaced by an estimate denoted by "e" in table R-1.

Table R-1.--Data for defining moisture relations in soils

M	DEPTH	RETENTION FORCE		VOLUME WEIGHT	AVERAGE VOLUME WEIGHT	SOIL MOISTURE	RETENTION CAPABILITY	ADSORPTION CAPABILITY	VOID MOISTURE CAPACITY	VOID MOISTURE	SOIL MOISTURE
	M	G/SQCM	PF	G/CC	G/CC	%	%	%	%	MOLECULAR LAYERS OF WATER	MOLECULAR LAYERS OF WATER
KIMBETO SITE 1 DATE OF SAMPLING:10/20/1976											
	0.10	157141.	5.20	1.37	1.37	1.83	6.36	10.18	35.07	35.1	2.9
	0.20	11839.	4.07	1.87	1.65	1.77	3.17	5.08	22.72	71.6	5.6
	0.30	6030.	3.78	1.72	1.87	1.78	2.82	4.51	15.83	58.2	6.3
	0.40	4437.	4.65	2.01	1.89	1.50	3.65	5.84	15.17	41.5	4.1
	0.50	3302.	4.52	1.94	1.93	1.83	4.14	6.62	14.16	34.2	4.4
	0.60	1253.	4.10	1.83	1.89	1.62	2.94	4.71	15.13	51.4	5.5
	0.70	1906.	3.28	1.90	1.89	1.86	2.45	3.33	15.16	51.8	7.6
	0.80	197.	2.29	1.94	1.90	1.88	1.86	2.98	14.86	79.9	10.1
	0.90	134.	2.13	1.86	1.88	2.09	1.99	3.18	15.35	77.3	10.5
	1.00	86.	1.94	1.85	1.89	2.21	2.00	3.20	15.17	75.8	11.0
	1.10	188.	2.27	1.96e	1.96	2.13	2.10	3.36	13.28	63.3	10.2
	1.20	70.	1.84	2.07e	2.07	3.07	2.73	4.36	10.57	38.7	11.3
	1.30	60.	1.78	2.18	2.13	3.46	3.02	4.84	9.21	30.5	11.5
	1.40	56.	1.74	2.13	2.11	3.59	3.11	4.98	9.41	30.9	11.5
	1.50	97.	1.99	2.02	1.97	5.75	5.27	8.43	13.14	24.9	10.9
	1.60	54.	1.73	1.74	1.85	9.50	8.21	13.14	16.32	19.9	11.6
	1.70	48.	1.68	1.78e	1.78	8.33	7.13	11.40	18.44	25.9	11.7
	1.80	41.	1.61	1.82e	1.82	7.81	6.58	10.53	17.21	26.2	11.9
	1.90	54.	1.73	1.86e	1.86	10.75	9.30	14.88	16.03	17.2	11.6
	2.00	40.	1.60	1.91	1.92	14.33	12.04	19.26	14.35	11.9	11.9
	2.10	17.	1.23	1.99	1.95	12.47	9.71	15.54	13.63	14.0	12.8
	2.20	20.	1.30		1.85e	16.36	12.92	20.67	16.36	12.7	12.7
	2.30	15.	1.17		1.90e	14.79	11.37	18.20	14.79	13.0	13.0
	2.40	18.	1.25		2.01e	12.10	9.66	15.13	12.10	12.8	12.8
	2.50	11.	1.05		1.78e	18.42	13.85	22.16	18.42	13.3	13.3
	2.60	5.	0.66	1.58	1.69	18.64	13.03	20.85	21.48	16.5	14.3
	2.70	4.	0.60	1.09	1.09	20.64	14.28	22.84	53.82	37.7	14.5
KIMBETO SITE 2 DATE OF SAMPLING:10/20/1976											
	0.10	9039.	3.96	1.24	1.24	1.11	1.90	3.03	42.76	225.6	5.9
	0.20	30.	1.47	1.49	1.40	4.19	3.42	5.48	33.69	98.4	12.2
	0.30	35.	1.54	1.47	1.50	4.42	3.67	5.86	29.10	79.4	12.1
	0.40	123.	2.09	1.53	1.50	4.06	3.81	6.10	29.04	76.1	10.6
	0.50	169.	2.23	1.49	1.49	1.84	1.83	2.94	29.33	159.9	10.3
	0.60	4290.	3.63	1.45	1.61	2.04	3.04	4.87	24.44	80.4	6.7
	0.70	2476.	3.39	1.98	1.85	2.46	3.37	5.39	16.28	48.3	7.3
	0.80	3222.	3.51	2.22	1.98	2.13	3.04	4.87	12.76	41.9	7.0
	0.90	4348.	3.64	1.84	2.05	2.76	4.13	6.62	11.07	26.8	6.7
	1.00	4358.	3.64	2.09	1.84	2.90	4.35	6.96	16.50	37.9	6.7
	1.10	7193.	3.86	1.60	1.81	1.91	3.12	4.99	17.39	55.8	6.1
	1.20	4976.	3.70	1.75	1.67	1.97	3.02	4.83	22.10	73.1	6.5
	1.30	5402.	3.73	1.66	1.69	1.54	2.40	3.84	21.29	88.7	6.4
	1.40	6311.	3.80	1.67	1.82	5.37	8.57	13.72	12.29	20.2	6.3
	1.50	5964.	3.78	2.12	2.04	4.03	6.36	10.18	11.21	17.6	6.3
	1.60	3578.	3.55	2.34	2.07	4.28	6.21	9.93	10.63	17.1	6.9
	1.70	3470.	3.54	1.75	2.02	4.01	5.79	9.27	11.68	20.2	6.9
	1.80	190.	2.28	1.99	1.78	5.34	5.25	8.40	18.37	35.0	10.2
	1.90	87.	1.94	1.61	1.84	6.84	6.20	9.93	16.72	27.0	11.0
	2.00	69.	1.80	1.91	1.77	7.35	6.45	10.32	18.79	29.1	11.4
	2.10	19.	1.28	1.79	1.91	5.80	5.34	8.55	14.71	27.5	12.7
	2.20	25.	1.39	2.03	2.00	9.15	6.55	10.49	12.31	18.8	12.4
	2.30	10.	1.01		1.91e	17.42	12.98	20.77	17.42	13.4	13.4
	2.40	6.	0.79		1.76e	19.19	13.74	21.98	19.19	14.0	14.0
	2.50	5.	0.72		1.65e	22.99	16.25	25.99	22.99	14.2	14.2
	2.60	5.	0.71		1.66e	22.39	15.78	25.25	22.39	14.2	14.2
	2.70	5.	0.71		1.69e	21.53	15.19	24.30	21.53	14.2	14.2

Table R-1.--Data for defining moisture relations in soils--Continued

M	DEPTH	RETENTION FORCE	PF	VOLUME WEIGHT	AVERAGE VOLUME WEIGHT	SOIL MOISTURE	RETENTION CAPABILITY	ADSORPTION CAPABILITY	VOID MOISTURE CAPACITY	VOID MOISTURE	SOIL MOISTURE
	M	G/SQCM		G/CC	G/CC	%	%	%	%	MOLECULAR LAYERS OF WATER	MOLECULAR LAYERS OF WATER
KIMBETO SITE 3 DATE OF SAMPLING:10/20/1976											
	0.10	305860.	5.49	1.13	1.13	3.98	16.45	26.33	50.86	30.9	2.4
	0.20	130281.	5.11	1.82	1.54	2.68	8.90	14.24	27.41	30.8	3.0
	0.30	127400.	5.11	1.65	1.80	1.46	4.84	7.74	17.96	37.1	3.0
	0.40	97013.	4.99	1.91	1.78	1.19	3.68	5.89	18.49	50.2	3.2
	0.50	93625.	4.97	1.77	1.95	1.20	3.67	5.86	13.51	36.9	3.3
	0.60	47881.	4.68	2.17	2.05	3.64	9.06	14.50	10.97	12.1	4.0
	0.70	58497.	4.77	2.22	2.15	3.34	8.82	14.11	8.70	9.9	3.8
	0.80	35391.	4.55	2.07	2.06	6.11	14.06	22.50	10.74	7.6	4.3
	0.90	47698.	4.68	1.90	1.83	7.33	18.24	29.19	17.00	9.3	4.0
	1.00	34813.	4.54	1.51	1.71	4.74	10.87	17.39	20.82	19.2	4.4
	1.10	45548.	4.66	1.72	1.57	1.69	4.17	6.67	25.79	61.9	4.1
	1.20	17409.	4.24	1.50	1.70	2.83	5.52	8.83	21.20	38.4	5.1
	1.30	28348.	4.45	1.88	1.64	6.55	14.25	22.80	23.26	14.3	4.6
	1.40	16933.	4.23	1.55	1.81	4.34	8.40	13.44	17.63	21.0	5.2
	1.50	18015.	4.26	2.00	1.66	6.94	13.61	21.78	22.50	16.5	5.1
	1.60	12868.	4.11	1.44	1.86	3.29	6.02	9.63	16.01	26.6	5.5
	1.70	17853.	4.25	2.15	1.72	3.01	5.89	9.43	20.40	34.6	5.1
	1.80	18082.	4.26	1.58	1.77	2.75	5.41	8.65	18.86	34.9	5.1
	1.90	19446.	4.29	1.58	1.65	2.34	4.68	7.48	22.92	49.0	5.0
	2.00	18640.	4.27	1.79	1.69	2.23	4.41	7.05	21.29	48.3	5.1
	2.10	17152.	4.23	1.71	1.77	2.48	4.81	7.69	18.83	39.2	5.2
	2.20	17147.	4.23	1.80	1.79	2.33	4.52	7.24	18.21	40.3	5.2
	2.30	20228.	4.31	1.85	1.99	2.29	4.61	7.38	12.54	27.2	5.0
	2.40	28951.	4.46	2.32	2.32	3.38	7.40	11.85	5.41	7.3	4.6
KIMBETO SITE 4 DATE OF SAMPLING:10/20/1976											
	0.10	515133.	5.71	1.00	1.00	1.92	9.74	14.94	62.06	66.5	2.1
	0.20	419245.	5.62	1.30	1.40	1.75	7.97	12.75	33.49	42.0	2.2
	0.30	445843.	5.65	1.92	1.68	1.70	7.88	12.61	21.97	27.7	2.2
	0.40	343220.	5.54	1.82	1.82	1.43	6.14	9.82	17.21	28.0	2.3
	0.50	262836.	5.42	1.72e	1.75	1.30	5.16	8.25	19.39	37.6	2.5
	0.60	114087.	5.06	1.71e	1.73	2.25	7.26	11.62	20.06	27.6	3.1
	0.70	105375.	5.02	1.76	1.69	4.85	15.36	24.57	21.44	14.0	3.2
	0.80	68651.	4.84	1.60	1.63	5.40	14.95	23.93	23.68	15.8	3.6
	0.90	66016.	4.82	1.53	1.64	7.12	19.48	31.16	23.24	11.9	3.7
	1.00	110741.	5.04	1.80e	1.69	4.09	13.10	20.96	21.44	16.4	3.1
	1.10	67234.	4.83	1.75	1.78	4.34	11.93	19.09	18.44	15.5	3.6
	1.20	39934.	4.60	1.80e	1.72	3.41	8.10	12.95	20.40	25.2	4.2
	1.30	31753.	4.50	1.61	1.64	2.63	5.90	9.43	23.24	39.4	4.5
	1.40	25335.	4.40	1.50	1.52	3.32	7.04	11.27	28.14	39.9	4.7
	1.50	19756.	4.30	1.45	1.60	5.21	11.82	18.91	24.80	21.0	5.0
	1.60	14385.	4.16	1.85	1.85	4.25	7.56	12.10	16.22	21.4	5.3
KIMBETO SITE 12 DATE OF SAMPLING:10/20/1975											
	0.10	636407.	5.80	0.85	0.85	8.34	43.67	69.87	79.63	18.2	1.9
	0.20	456317.	5.66	1.97	1.78	10.84	50.65	81.04	18.59	3.7	2.1
	0.30	458532.	5.66		2.00e	12.27	57.42	91.88	12.27	2.1	2.1
	0.40	450480.	5.65		1.91e	14.72	68.51	109.61	14.72	2.1	2.1
	0.50	330569.	5.52	2.06	1.87	13.17	56.71	89.13	15.64	2.8	2.4
	0.60	290933.	5.46		1.94e	13.90	56.70	90.72	13.90	2.5	2.5
	0.70	339108.	5.53		1.92e	14.43	61.51	98.41	14.43	2.3	2.3
	0.80	206564.	5.32		1.90e	14.80	55.02	88.03	14.80	2.7	2.7
	0.90	318761.	5.50		1.94e	13.93	58.31	93.30	13.93	2.4	2.4
	1.00	251161.	5.40		1.91e	14.65	57.37	91.80	14.65	2.6	2.6

Table R-1.--Data for defining moisture relations in soils--Continued

H DEPTH	RETENTION FORCE		VOLUME WEIGHT	AVERAGE VOLUME WEIGHT	SOIL MOISTURE	RETENTION CAPABILITY	ADSORPTION CAPABILITY	VOID MOISTURE CAPACITY	VOID MOISTURE	SOIL MOISTURE
M	G/SQCM	PF	G/CC	G/CC	%	%	%	%	MOLECULAR LAYERS OF WATER	MOLECULAR LAYERS OF WATER
KIMBETO SITE 5 DATE OF SAMPLING:10/20/1976										
0.10	159814.	5.20	1.10	1.10	1.74	6.08	9.72	52.83	86.9	2.9
0.20	19637.	4.29	1.34	1.40	3.13	6.26	10.01	33.90	54.2	5.0
0.30	16447.	4.22	1.24	1.56	3.10	5.37	9.55	26.18	43.9	5.2
0.40	15774.	4.20	1.61	1.40	5.09	9.70	15.51	33.73	34.8	5.2
0.50	14363.	4.16	1.35	1.59	7.47	13.95	22.33	25.10	18.0	5.4
0.60	35306.	4.55	1.82	1.51	5.38	12.36	19.77	28.48	23.1	4.4
0.70	41849.	4.62	1.37	1.44	4.80	11.55	18.48	31.83	27.6	4.2
0.80	48104.	4.68	1.13	1.35	3.80	9.48	15.17	36.41	38.4	4.0
0.90	34131.	4.53	1.55	1.50	3.12	7.11	11.37	28.72	40.4	4.4
1.00	41164.	4.61	1.83	1.58	1.99	4.76	7.62	25.39	53.3	4.2
1.10	50992.	4.71	1.37	1.76	1.62	4.12	6.59	19.12	46.4	3.9
1.20	55382.	4.74	2.07	1.73	2.02	5.25	8.40	20.05	38.2	3.8
1.30	35952.	4.56	1.75	1.89	3.81	9.79	14.07	15.12	17.2	4.3
1.40	42718.	4.63	1.85	1.86	8.39	20.27	32.43	15.91	7.9	4.1
1.50	40922.	4.61	1.99	1.89	6.97	16.64	26.62	15.10	9.1	4.2
1.60	46286.	4.67	1.94	2.07	5.24	12.94	20.71	10.54	8.1	4.0
1.70	25313.	4.40	2.39	2.11	2.17	4.59	7.35	9.75	21.2	4.7
1.80	36281.	4.56	2.09	2.06	2.33	5.40	8.64	10.70	19.8	4.3
1.90	33026.	4.52	1.71	1.82	3.43	7.76	12.41	17.20	22.2	4.4
2.00	30826.	4.49	1.66	1.69	3.72	8.27	13.24	21.62	26.1	4.5
2.10	36461.	4.56	1.69	1.68	5.47	12.67	20.27	21.95	17.3	4.3
2.20	32386.	4.51	1.66	1.77	5.57	12.53	20.05	18.82	15.0	4.4
2.30	36250.	4.56	1.94	1.86	8.54	19.77	31.63	15.96	8.1	4.3
2.40	40056.	4.60	1.97	1.97	7.21	17.13	27.41	13.03	7.6	4.2
KIMBETO SITE 6 DATE OF SAMPLING:10/20/1976										
0.10	31867c.	5.50	1.32	1.32	4.01	16.77	26.83	38.30	22.8	2.4
0.20	22030.	4.34	1.59	1.54	5.17	10.41	16.97	27.23	25.7	4.9
0.30	319254.	5.50	1.71	1.56	1.85	7.74	12.38	22.42	29.2	2.4
0.40	240898.	5.38	1.67	1.64	2.63	9.39	15.02	22.60	24.1	2.6
0.50	151450.	5.18	1.40	1.59	4.42	15.22	24.35	25.09	16.5	2.9
0.60	126540.	5.10	1.51	1.60	4.18	13.79	22.07	24.94	18.1	3.0
0.70	109354.	5.04	1.69	1.56	4.76	15.21	24.33	26.51	17.4	3.1
0.80	98480.	4.99	1.48	1.60	7.94	24.73	39.57	24.92	10.1	3.2
0.90	62811.	4.80	1.63	1.58	7.93	21.38	34.20	25.56	12.0	3.7
1.00	53222.	4.73	1.63	1.57	6.90	17.72	28.36	25.83	14.6	3.9
1.10	67474.	4.83	1.46	1.65	7.74	21.32	34.11	22.72	10.7	3.6
1.20	72220.	4.86	1.87	1.87	6.11	17.20	27.52	15.68	9.1	3.6
KIMBETO SITE 7 DATE OF SAMPLING:10/20/1976										
0.10	184527.	5.27	1.25	1.25	3.66	13.22	21.16	42.04	31.8	2.8
0.20	48190.	4.68	1.75	1.55	8.16	20.37	32.60	26.59	13.1	4.0
0.30	60723.	4.78	1.66	1.65	6.67	17.81	28.49	22.95	12.9	3.7
0.40	143925.	5.16	1.53	1.63	3.15	10.72	17.15	23.57	22.0	2.9
0.50	104036.	5.02	1.70	1.63	2.87	9.06	14.49	23.55	24.0	3.2
0.60	126300.	5.10	1.66	1.66	1.55	5.11	8.17	22.56	44.2	3.0
0.70	122329.	5.09	1.61	1.68	3.97	13.02	20.83	21.79	16.7	3.1
0.80	104302.	5.02	1.77	1.67	3.77	11.91	19.05	22.06	18.5	3.2
0.90	63227.	4.80	1.63	1.69	5.80	15.65	25.05	21.42	13.7	3.7
1.00	76307.	4.88	1.67	1.72	5.26	15.07	24.11	20.50	13.6	3.5
1.10	67473.	4.83	1.85	1.62	3.47	9.56	15.29	23.91	25.0	3.6
1.20	69256.	4.84	1.35	1.35	3.80	10.56	16.89	36.35	34.4	3.6

Table R-1--Data for defining moisture relations in soils--Continued

H DEPTH	RETENTION FORCE		VOLUME WEIGHT	AVERAGE VOLUME WEIGHT	SOIL MOISTURE	RETENTION CAPABILITY	ADSORPTION CAPABILITY	VOID MOISTURE CAPACITY	VOID MOISTURE	SOIL MOISTURE
M	G/SQCM	PF	G/CC	G/CC	%	%	%	%	MOLECULAR LAYERS OF WATER	MOLECULAR LAYERS OF WATER
KIMBETO SITE 8 DATE OF SAMPLING:10/20/1976										
0.10	28614.	4.46	1.37	1.37	2.45	5.35	8.56	35.36	66.1	4.6
0.20	6095.	3.78	1.95	1.73	3.41	5.41	8.66	20.20	37.3	6.3
0.30	15617.	4.19	1.86	1.89	3.56	6.77	10.83	15.09	22.3	5.3
0.40	28172.	4.45	1.87	1.74	4.41	9.58	15.33	19.62	20.5	4.6
0.50	36030.	4.56	1.58	1.73	3.57	8.26	13.22	19.93	24.1	4.3
0.60	47650.	4.68	1.63	1.66	4.48	11.15	17.83	22.58	20.3	4.0
0.70	58777.	4.84	1.64	1.70	4.21	11.67	18.67	21.20	18.2	3.6
0.80	74138.	4.87	1.62	1.64	3.71	10.53	16.85	23.34	22.2	3.5
0.90	48514.	4.69	1.65	1.62	3.53	8.83	14.12	24.15	27.4	4.0
1.00	65424.	4.82	1.58	1.75	3.75	10.25	16.40	19.56	19.1	3.7
1.10	65505.	4.82	2.01	1.81	4.35	11.87	18.99	17.46	14.7	3.7
1.20	74585.	4.87	1.85	1.90	4.27	12.13	19.41	14.94	12.3	3.5
1.30	55530.	4.74	1.84	1.78	4.48	11.66	18.65	18.35	15.7	3.8
1.40	53201.	4.73	1.66	1.74	4.19	10.75	17.20	19.81	18.4	3.9
1.50	15982.	4.20	1.71	1.65	3.97	7.59	12.15	23.04	30.4	5.2
1.60	64907.	4.81	1.56	1.75	4.14	11.28	18.05	19.33	17.1	3.7
1.70	34143.	4.53	1.98	1.67	4.53	10.32	16.51	22.28	21.6	4.4
1.80	38510.	4.59	1.45	1.74	4.48	10.52	16.84	19.79	18.8	4.1
1.90	42790.	4.63	1.78	1.64	4.50	10.87	17.40	23.38	21.5	4.1
2.00	45306.	4.66	1.68	1.82	3.88	9.54	15.26	17.24	18.1	4.1
2.10	121831.	5.09	2.00	1.84	3.47	11.36	18.18	16.68	14.7	3.1
2.20	42669.	4.63	1.83	1.94	4.04	9.75	15.61	13.86	14.2	4.1
2.30	43485.	4.64	1.98	1.99	4.69	11.38	18.21	12.65	11.0	4.1
2.40	43214.	4.64	2.16	2.16	3.62	8.77	14.03	8.67	9.9	4.1
KIMBETO SITE 9 DATE OF SAMPLING:10/20/1976										
0.10	165856.	5.22	2.11	2.11	1.45	5.10	8.16	9.65	18.9	2.8
0.20	30979.	4.49	1.96	2.00	2.17	4.83	7.73	12.22	25.3	4.5
0.30	32098.	4.51	1.92	1.92	2.54	5.71	9.14	14.25	25.0	4.5
0.40	30315.	4.48	1.83	1.84	2.34	5.18	8.29	16.60	32.1	4.5
0.50	31639.	4.50	1.73	1.75	2.40	5.37	8.59	19.43	36.2	4.5
0.60	43976.	4.64	1.65	1.71	2.22	5.40	8.64	20.67	38.3	4.1
0.70	48295.	4.68	1.76	1.73	2.13	5.31	8.50	20.05	37.7	4.0
0.80	36521.	4.56	1.78	1.74	2.44	5.65	9.04	19.82	35.1	4.3
0.90	33373.	4.52	1.67	1.84	2.40	5.43	8.69	16.51	30.4	4.4
1.00	41548.	4.62	2.08	1.96	2.30	5.51	8.82	13.28	24.1	4.2
1.10	43517.	4.64	2.14 e	2.14	2.46	5.98	9.57	8.56	14.3	4.1
1.20	53984.	4.73	2.20 e	2.20	2.55	6.57	10.52	7.72	11.8	3.9
1.30	35483.	4.55	2.26	2.24	2.54	5.84	9.35	6.91	11.8	4.3
1.40	36400.	4.56	2.25	2.35	2.69	6.24	9.98	4.90	7.9	4.3
1.50	37107.	4.57	2.53	2.43	2.26	5.27	8.44	3.34	4.3	4.3
1.60	20239.	4.31		2.49 e	2.50	5.04	8.06	2.50	5.0	5.0
1.70	34137.	4.53	2.45	2.37	2.82	6.42	10.28	4.51	7.0	4.4
1.80	43723.	4.64	2.13	2.22	4.13	10.03	16.05	7.28	7.3	4.1
1.90	193.	2.29	2.09	2.28	5.75	5.67	9.07	6.06	10.7	10.1
2.00	24284.	4.39		2.13 e	9.09	19.08	30.53	9.09	4.8	4.8
2.10	27402.	4.44		2.03 e	11.63	25.10	40.16	11.63	4.6	4.6
2.15	26750.	4.43		2.27 e	6.35	13.63	21.80	6.35	4.7	4.7
KIMBETO SITE 17 DATE OF SAMPLING:10/20/1976										
0.10	34383.	4.54	1.10	1.10	6.09	13.91	22.25	53.04	38.1	4.4
0.20	25244.	4.40	1.04	1.15	11.85	25.10	40.15	49.05	19.5	4.7
0.30	38381.	4.58	1.31	1.45	12.20	28.64	45.83	31.10	10.9	4.3
0.40	47004.	4.67	2.00	1.58	8.52	21.14	33.82	25.73	12.2	4.0
0.50	52833.	4.72	1.41	1.72	7.53	20.88	33.41	20.36	9.8	3.7
0.58	55557.	4.74	1.75	1.75	7.04	18.30	29.29	19.34	10.6	3.8

Table R-1.--Data for defining moisture relations in soils--Continued

H	DEPTH	RETENTION FORCE	VOLUME WEIGHT	AVERAGE VOLUME WEIGHT	SOIL MOISTURE	RETENTION CAPABILITY	ADSORPTION CAPABILITY	VOID MOISTURE CAPACITY	VOID MOISTURE	SOIL MOISTURE
	M	G/SQCM PF	G/CC	G/CC	%	%	%	%	MOLECULAR LAYERS OF WATER	MOLECULAR LAYERS OF WATER
KIMBETO SITE 10 DATE OF SAMPLING:10/20/1976										
	0.10	223503. 5.35	1.26	1.26	2.97	11.28	18.04	41.50	36.8	2.6
	0.20	43797. 4.64	1.55	1.41	5.60	13.63	21.81	33.11	24.3	4.1
	0.30	35570. 4.55	1.42	1.51	5.90	13.60	21.75	28.38	20.9	4.3
	0.40	28291. 4.45	1.57	1.50	5.52	12.00	19.20	29.07	24.2	4.6
	0.50	42030. 4.62	1.50	1.50	5.93	14.28	22.84	28.93	20.3	4.2
	0.60	43289. 4.64	1.43	1.44	5.90	14.30	22.89	31.82	22.2	4.1
	0.70	67455. 4.83	1.38	1.42	6.48	17.85	28.55	32.87	18.4	3.6
	0.80	89684. 4.95	1.44	1.43	6.16	18.61	29.77	32.17	17.3	3.3
	0.90	68010. 4.83	1.47	1.51	5.94	16.47	26.35	28.58	17.4	3.6
	1.00	68563. 4.84	1.61	1.56	5.05	13.99	22.39	26.24	18.8	3.6
	1.10	84918. 4.93	1.61	1.60	5.16	15.30	24.48	24.60	16.1	3.4
	1.20	45853. 4.66	1.60	1.70	6.21	15.30	24.48	21.22	13.9	4.1
	1.30	56757. 4.75	1.89	1.88	5.34	13.96	22.34	15.35	11.0	3.8
	1.40	57016. 4.76	2.17	2.01	3.57	9.36	14.97	11.99	12.8	3.8
	1.50	44301. 4.65	1.98	1.97	3.02	7.36	11.78	13.00	17.6	4.1
	1.60	44943. 4.65	1.77	1.89	2.74	6.70	10.73	15.14	22.6	4.1
	1.70	39237. 4.59	1.93	1.88	3.12	7.37	11.79	15.45	21.0	4.2
	1.80	33732. 4.53	1.95	1.86	2.13	4.84	7.74	16.02	33.1	4.4
	1.90	28531. 4.46	1.71	1.89	2.98	6.49	10.38	15.31	23.6	4.6
	2.00	36721. 4.56	2.00	1.87	2.64	6.12	9.79	15.64	25.6	4.3
	2.10	28447. 4.45	1.91	1.91	2.09	4.55	7.29	14.76	32.4	4.6
	2.20	28641. 4.46	1.80	1.89	1.67	3.65	5.83	15.13	41.5	4.6
	2.30	35411. 4.55	1.96	1.97	1.73	3.99	6.38	12.92	32.4	4.3
	2.40	26877. 4.43	2.16	2.16	2.67	5.74	9.19	8.67	14.9	4.7
KIMBETO SITE 11 DATE OF SAMPLING:10/20/1976										
	0.10	66761. 4.82	1.31	1.31	3.29	9.01	14.41	38.81	43.1	3.6
	0.20	6897. 3.84	1.52	1.41	6.69	10.84	17.35	33.00	30.4	6.2
	0.30	3958. 3.60	1.42	1.47	8.58	12.25	19.59	30.08	24.6	7.0
	0.40	2191. 3.34	1.49	1.50	9.34	12.55	20.09	29.06	23.1	7.4
	0.50	2067. 3.32	1.59	1.57	9.51	12.67	20.27	25.83	20.4	7.5
	0.60	1823. 3.26	1.64	1.62	9.31	12.17	19.47	24.08	19.8	7.5
	0.70	3016. 3.48	1.62	1.61	8.79	13.82	22.11	24.25	17.5	7.1
	0.80	2906. 3.46	1.57	1.51	10.37	14.55	23.27	28.42	19.5	7.1
	0.90	3037. 3.48	1.34	1.56	8.81	12.45	19.92	26.55	21.3	7.1
	1.00	5700. 3.76	1.75	1.59	8.89	13.94	22.30	25.02	18.0	6.4
	1.10	13440. 4.13	1.69	1.66	7.60	14.00	22.40	22.45	16.0	5.4
	1.20	35211. 4.55	1.54	1.72	6.02	13.82	22.11	20.46	14.8	4.4
	1.30	56493. 4.75	1.92	1.67	6.15	16.07	25.72	22.12	13.8	3.8
	1.40	82097. 4.91	1.55	1.77	6.06	17.77	28.43	18.69	10.5	3.4
	1.50	54981. 4.74	1.85	1.68	6.60	17.11	27.37	21.69	12.7	3.9
	1.60	58119. 4.76	1.66	1.66	5.54	14.60	23.36	22.66	15.5	3.8
KIMBETO SITE 16 DATE OF SAMPLING:10/20/1976										
	0.10	88557. 4.95	1.37	1.37	1.90	5.72	9.15	35.07	41.3	3.3
	0.20	11851. 4.07	1.82	1.79	2.87	5.15	8.25	18.09	35.1	5.6
	0.30	25635. 4.41	2.18	1.98	2.42	5.15	8.24	12.66	24.6	4.7
	0.40	28520. 4.46	1.95	2.09	3.97	8.65	13.84	10.19	11.8	4.6
	0.50	52270. 4.72	2.13	2.08	4.12	11.53	16.85	10.33	9.8	3.9
	0.60	67466. 4.83	2.16	2.14	3.45	9.51	15.22	8.91	9.4	3.6
	0.70	39157. 4.59	2.14	2.05	3.11	7.34	11.74	11.02	15.0	4.2
	0.80	86005. 4.93	1.85	1.88	3.19	8.74	13.98	15.51	17.7	3.7
	0.90	62448. 4.80	1.64	1.70	2.92	7.87	12.58	21.22	27.0	3.7
	1.00	42640. 4.63	1.60	1.39	3.52	8.50	13.61	15.14	17.8	4.1
	1.10	58951. 4.77	2.44	1.99	4.29	11.34	18.15	12.58	11.1	3.8
	1.20	64927. 4.81	1.93	2.30	4.56	12.41	19.86	5.84	4.7	3.7
	1.25	51602. 4.71		2.35e	4.74	12.07	19.30	4.74	3.9	3.9

Table R-1.--Data for defining moisture relations in soils--Continued

H	DEPTH	RETENTION FORCE		VOLUME WEIGHT	AVERAGE VOLUME WEIGHT	SOIL MOISTURE	RETENTION CAPABILITY	ADSORPTION CAPABILITY	VOID MOISTURE CAPACITY	VOID MOISTURE	SOIL MOISTURE
	M	G/SQCM	PF	G/CC	G/CC	%	%	%	%	MOLECULAR LAYERS OF WATER	MOLECULAR LAYERS OF WATER
KIMBETO SITE 13 DATE OF SAMPLING:10/20/1976											
	0.10	26256.	4.42	1.38	1.38	2.71	5.79	9.27	34.58	59.7	4.7
	0.20	179940.	5.26	0.72	1.13	2.07	7.43	11.89	51.09	58.8	2.8
	0.30	26158.	4.42	1.28	1.51	3.01	6.42	10.28	28.38	44.2	4.7
	0.40	27013.	4.43	2.54	1.84	2.97	6.39	10.22	16.72	26.2	4.6
	0.50	33299.	4.52	1.69	2.01	2.90	6.56	10.49	12.07	18.4	4.4
	0.60	54154.	4.73	1.79	1.73	2.58	6.67	10.67	20.17	30.2	3.9
	0.70	58453.	4.77	1.70	1.72	2.82	7.43	11.89	20.25	27.3	3.8
	0.80	66411.	4.82	1.68	1.71	2.73	7.49	11.98	20.58	27.5	3.6
	0.90	78825.	4.90	1.77	1.76	2.88	8.33	13.32	19.12	23.0	3.5
	1.00	54744.	4.74	1.83	1.98	3.15	8.16	13.05	12.85	15.7	3.9
	1.10	75302.	4.88	2.33	2.08	3.02	8.62	13.79	10.34	12.0	3.5
	1.20	73394.	4.87	2.08	2.26	3.07	8.67	13.88	6.61	7.6	3.5
	1.30	60284.	4.78	2.36	2.22	3.69	9.82	15.70	7.23	7.4	3.8
	1.40	65557.	4.82	2.24	2.23	3.86	7.81	12.50	7.06	9.0	3.7
	1.50	54530.	4.74	2.10	2.20	2.91	7.53	12.05	7.72	10.3	3.9
	1.60	43804.	4.64	2.25 e	2.21	3.48	8.46	13.54	7.51	8.8	4.1
	1.70	33799.	4.53	2.28	2.26	3.77	8.57	13.72	6.51	7.6	4.4
	1.80	37264.	4.57	2.24	2.33	3.06	7.13	11.41	5.16	7.2	4.3
	1.90	19448.	4.29	2.48	2.35	2.55	5.09	8.14	4.85	9.5	5.0
	2.00	12053.	4.08	2.33	2.30	2.80	5.05	8.07	5.67	11.2	5.5
	2.10	6309.	3.80	2.11	2.20	2.69	4.29	6.87	7.80	18.2	6.3
	2.20	3546.	3.55	2.15	2.03	2.98	4.31	6.90	11.49	26.6	6.9
	2.30	4608.	3.66	1.83	2.07	3.10	4.68	7.49	10.68	22.8	6.6
	2.40	6134.	3.79	2.21	2.21	2.72	4.32	6.91	7.48	17.3	6.3
KIMBETO SITE 19 DATE OF SAMPLING:10/20/1976											
	0.10	93912.	4.97	1.16	1.16	6.81	20.89	33.42	48.59	23.3	3.3
	0.20	76344.	4.88	1.93	1.60	7.81	22.37	35.79	24.65	11.0	3.5
	0.30	74080.	4.87	1.72	1.72	10.99	31.16	49.86	20.51	6.6	3.5
	0.40	75074.	4.88	1.50	1.59	13.98	39.90	63.69	25.34	6.4	3.5
	0.50	72010.	4.86	1.53	1.53	13.72	38.57	61.71	27.60	7.2	3.6
	0.60	61004.	4.61	1.56	1.79	14.23	34.01	54.42	18.16	5.3	4.2
	0.70	46437.	4.67	2.28	1.81	13.88	34.31	54.90	17.43	5.1	4.0
	0.80	36125.	4.56		1.88 e	15.51	35.87	57.39	15.51	4.3	4.3
	0.90	33173.	4.52		1.91 e	14.59	33.01	52.82	14.59	4.4	4.4
	1.00	39102.	4.59		1.93 e	14.12	33.34	53.34	14.12	4.2	4.2
KIMBETO SITE 21 DATE OF SAMPLING:10/20/1976											
	0.10	108186.	5.03	1.47	1.47	3.70	11.80	18.87	30.47	25.8	3.1
	0.20	49406.	4.69	1.48	1.57	3.85	9.71	15.53	27.85	28.7	4.0
	0.30	56071.	4.75	1.63	1.57	3.40	8.86	14.18	26.12	29.5	3.8
	0.40	38551.	4.59	1.59	1.61	3.48	8.16	13.06	24.41	29.9	4.3
	0.50	43475.	4.64	1.61	1.63	3.34	8.10	12.96	23.45	29.0	4.1
	0.60	45960.	4.66	1.70	1.63	3.25	8.01	12.81	23.50	29.3	4.1
	0.70	39062.	4.59	1.59	1.71	3.64	8.58	13.74	20.60	24.0	4.2
	0.80	35693.	4.55	1.86	1.92	3.67	8.46	13.54	14.29	16.9	4.3
	0.90	42272.	4.63	2.32	1.97	3.69	8.90	14.24	12.69	14.6	4.2
	1.00	33880.	4.53	1.73	2.12	2.82	6.40	10.25	9.39	14.7	4.4
	1.10	50912.	4.71	2.31	1.93	2.76	6.99	11.19	14.21	20.3	3.9
	1.20	52054.	4.72	1.73	1.96	2.76	7.05	11.27	13.26	19.8	3.9
	1.30	31436.	4.50	1.84	1.87	2.73	6.10	9.75	15.84	26.0	4.5
	1.40	45941.	4.66	2.02	1.95	2.78	6.84	10.95	13.57	19.8	4.1
	1.50	46939.	4.67	1.98	1.97	3.16	7.85	12.55	13.11	16.7	4.0
	1.60	25695.	4.41	1.90	1.90	4.01	8.52	13.63	13.11	16.7	4.7

Table R-1--Data for defining moisture relations in soils--Continued

H DEPTH	RETENTION FORCE		VOLUME WEIGHT	AVERAGE VOLUME WEIGHT	SOIL MOISTURE	RETENTION CAPABILITY	ADSORPTION CAPABILITY	VOID MOISTURE CAPACITY	VOID MOISTURE	SOIL MOISTURE
*	G/SQCM	PF	G/CC	G/CC	%	%	%	%	MOLECULAR LAYERS OF WATER	MOLECULAR LAYERS OF WATER
KIMBETO SITE 20 DATE OF SAMPLING:10/20/1976										
0.10	131275.	5.12	1.42	1.42	2.22	7.38	11.81	32.48	44.0	3.0
0.20	18853.	4.28	1.74	1.67	3.58	7.09	11.34	22.21	31.3	5.0
0.30	29507.	4.47	1.84	1.82	3.98	8.53	13.65	17.36	20.3	4.5
0.40	24912.	4.40	1.86	1.89	5.56	11.72	18.76	15.18	12.9	4.7
0.50	24444.	4.39	1.96	1.91	5.06	10.62	16.99	14.60	13.7	4.8
0.60	42085.	4.62	1.91	1.87	3.55	8.54	13.66	15.84	18.6	4.2
0.70	62570.	4.80	1.73	1.77	3.05	8.20	13.13	18.88	23.0	3.7
0.80	47518.	4.68	1.66	1.63	3.77	9.39	15.02	23.69	25.2	4.0
0.90	56388.	4.75	1.49	1.58	8.17	21.34	34.15	25.40	11.9	3.8
1.00	63538.	4.80	1.60	1.68	6.51	17.61	28.17	21.79	12.4	3.7
1.10	53193.	4.73	1.94 e	1.83	7.03	18.06	28.89	17.06	9.4	3.9
1.20	56804.	4.75	1.94 e	2.00	5.58	14.59	23.35	12.25	8.4	3.8
1.30	52620.	4.72	2.13	2.13	5.66	14.49	23.18	9.27	6.4	3.9
KIMBETO SITE 14 DATE OF SAMPLING:10/20/1976										
0.10	120167.	5.08	1.03	1.03	5.27	17.19	27.50	59.34	34.5	3.1
0.20	87322.	4.94	1.54	1.38	12.12	36.27	58.03	34.79	9.6	3.3
0.30	113970.	5.06	1.56	1.49	9.81	31.62	50.60	29.35	9.3	3.1
0.40	65837.	4.82	1.37	1.45	15.74	42.99	68.78	31.22	7.3	3.7
0.50	69547.	4.84	1.42	1.41	14.29	50.87	81.39	33.25	6.5	3.6
0.60	65467.	4.82	1.44	1.39	20.12	54.91	87.86	33.98	6.2	3.7
0.70	13948.	4.14	1.32	1.42	20.60	38.26	61.22	32.74	8.6	5.4
0.80	58321.	4.77	1.49	1.44	20.26	53.44	85.50	31.69	5.9	3.8
0.90	55018.	4.74	1.50	1.51	24.14	62.59	100.14	28.55	4.6	3.9
1.00	41141.	4.61		1.59 e	25.04	59.90	95.84	25.04	4.2	4.2
1.10	52128.	4.72		1.68 e	21.64	55.25	88.41	21.64	3.9	3.9
KIMBETO SITE 15 DATE OF SAMPLING:10/20/1976										
0.10	86253.	4.94	1.30	1.30	2.01	6.00	9.60	39.28	65.5	3.4
0.20	15292.	4.18	2.46	1.90	2.53	4.79	7.67	14.81	30.9	5.3
0.30	25416.	4.41	1.95	2.03	2.85	6.05	9.68	11.60	19.2	4.7
0.40	23922.	4.38	1.67	1.78	2.95	6.17	9.88	18.57	30.1	4.8
0.50	18576.	4.27	1.70	1.74	2.52	4.97	7.96	19.62	38.4	5.1
0.60	26414.	4.42	1.86	1.81	2.31	4.95	7.92	17.46	35.3	4.7
0.70	21804.	4.34	1.88	1.94	5.34	10.92	17.48	12.71	11.6	4.9
0.80	19355.	4.29	2.22	1.96	7.73	15.40	24.64	13.38	8.7	5.0
0.90	22938.	4.36	1.78	1.90	7.16	14.82	23.71	14.90	10.1	4.8
1.00	29757.	4.47	1.71	1.72	7.23	15.92	25.47	20.42	12.8	4.5
1.10	17388.	4.24	1.67	1.73	6.91	13.25	21.20	20.17	15.2	5.1
1.20	20804.	4.32	1.80	1.73	6.35	12.87	20.60	20.00	15.5	4.9
1.30	27688.	4.44	1.72	1.80	4.39	9.49	15.18	17.68	18.6	4.6
1.40	24350.	4.39	1.89	1.72	4.09	8.59	13.75	20.51	23.9	4.8
1.50	19011.	4.28	1.54	1.80	6.48	12.87	20.59	17.87	13.9	5.0
1.60	24503.	4.39	1.97	1.71	5.94	12.50	19.99	20.64	16.5	4.8
1.70	22028.	4.34	1.64	1.90	8.17	16.77	26.83	14.79	9.8	4.9
1.80	31929.	4.50		1.83 e	16.86	37.79	60.46	16.86	4.5	4.5
1.90	24422.	4.39	1.79	1.86	13.40	28.16	45.05	15.99	5.7	4.8
2.00	20414.	4.31	1.69	1.77	14.60	29.44	47.11	19.72	6.4	5.0
2.10	20482.	4.31	1.84	1.74	13.97	28.19	45.10	19.24	6.8	5.0
2.20	24941.	4.40		1.86 e	16.10	34.00	54.40	16.10	4.7	4.7
2.30	20945.	4.32		1.88 e	15.50	31.43	50.29	15.50	4.9	4.9
2.40	20027.	4.30		1.75 e	19.33	38.81	62.10	19.33	5.0	5.0

Table R-1.--Data for defining moisture relations in soils--Continued

H DEPTH	RETENTION FORCE	VOLUME WEIGHT	AVERAGE VOLUME WEIGHT	SOIL MOISTURE	RETENTION CAPABILITY	ADSORPTION CAPABILITY	VOID MOISTURE CAPACITY	VOID MOISTURE	SOIL MOISTURE
M	G/SQCM PF	G/CC	G/CC	%	%	%	%	MOLECULAR LAYERS OF WATER	MOLECULAR LAYERS OF WATER
KIMBETO SITE 1B DATE OF SAMPLING:10/20/1976									
0.10	16475. 4.22	1.10	1.10	4.22	8.11	12.97	53.16	65.6	5.2
0.20	11820. 4.07	1.50	1.35	5.14	9.23	14.77	36.44	39.5	5.6
0.30	23215. 4.37	1.45	1.49	4.84	10.05	16.08	29.97	29.8	4.8
0.40	47718. 4.68	1.49	1.47	4.51	11.24	17.99	30.19	24.9	4.0
0.50	56563. 4.77	1.48	1.49	4.46	11.77	18.83	29.39	25.0	3.8
0.60	59551. 4.77	1.50	1.51	4.44	11.79	18.86	28.49	24.2	3.8
0.70	63223. 4.80	1.55e	1.55	4.50	12.16	19.46	26.78	22.0	3.7
0.80	72416. 4.86	1.60	1.54	4.71	13.27	21.23	27.20	20.5	3.6
0.90	53759. 4.73	1.46e	1.46	4.77	12.28	19.65	30.76	25.1	3.9
1.00	84514. 4.93	1.32	1.35	5.97	17.66	28.24	36.34	20.6	3.4
1.10	103166. 5.01	1.26	1.14	4.14	13.05	20.89	50.23	38.5	3.2
1.20	79028. 4.90	0.82	0.82	3.30	9.55	15.28	83.86	87.8	3.5

Table R-2
CONVERSION FACTORS

S. I.	Multiply by	Customary
mm (millimeters)	.03937	inches (in.)
m (meters)	39.37	inches (in.)
g/cm^3, g/cc (grams per cubic centimeter	62.43	pounds per cubic foot (lb/ft^3)
g/cm^2 (grams per square centimeter)	.01422	pounds per square inch (psi)
	9.678×10^{-4}	atmospheres (atm)
	9.806×10^{-4}	bars
log (grams per square centimeter)	1.0	pF

The data in **table R-1 were computed from the following** equations:

VW = weight of soil ÷ 202.683

VMC = (1 ÷ VW) − (1 ÷ 2.65)

pF = 6.24617 − (0.0723 X PM) if PM ≤ 54%

pF = 2.8948 − (0.01025 X PM) if PM > 54%

STRESS = 10^{pF}

AMC = (6.24617 X SM) ÷ (6.24617 − pF) if PF < 5.0

AMC = (10.0246 X SM) / (7 − pF) if pF ≥ 5.0

MRC = AMC X 0.625

SM (molecular layers of water) = (soil moisture ÷ MRC) X 10.0

VMC (molecular layers of water) = (VMC ÷ MRC) X 10

Vegetation cover measurements were made at each soil sampling site by the first-contact method. The first contact of a boot toe was recorded for 100 steps during a random walk through the associated vegetation type in the immediate area. Soils are normally sampled when soil moisture storage is at or near a minimum because of depletion by evapotranspiration. Hence, the soil moisture content at the time of sampling is designated minimum storage (MS). For each depth increment, the quantity of water that can be retained between MRC and MS and between VMC and MRC was computed as follows:

$$\left[(\text{MRC} - \text{MS}) \times \frac{\text{VW}}{100} \times \frac{\text{depth of increment in mm}}{1\ \text{g/cm}^3}\right] \quad \text{and}$$

$$\left[(\text{VMC} - \text{MRC}) \times \frac{\text{VW}}{100} \times \frac{\text{depth of increment in mm}}{1\ \text{g/cm}^3}\right]$$

The incremented values are summed to the depth of constrictions where MRC becomes less than MS and where VMC becomes less than MRC or to the base of the profile if constrictions are nonexistent. The resulting sums are profile values reported in depth-area millimeters of water, just as precipitation is reported in metric units.

The quantity of water that can be held in the profile between MRC and MS levels represents the normal annual maximum recharge or normal peak storage. The peak storage may occur over the fall, winter, and early spring from rain and snowmelt, or it may occur during a rainy period in the summer. Quantities of water added from precipitation events other than those that cause the peak storage are not included. The normal peak storage, therefore, is only an index of normal annual evapotranspiration.

Table R-2
CONVERSION FACTORS

S. I.	Multiply by	Customary
mm (millimeters)	.03937	inches (in.)
m (meters)	39.37	inches (in.)
g/cm^3, g/cc (grams per cubic centimeter	62.43	pounds per cubic foot (lb/ft^3)
g/cm^2 (grams per square centimeter)	.01422	pounds per square inch (psi)
	9.678×10^{-4}	atmospheres (atm)
	9.806×10^{-4}	bars
log (grams per square centimeter)	1.0	pF

The data in **table R-1 were computed from the following** equations:

VW = weight of soil ÷ 202.683

VMC = (1 ÷ VW) − (1 ÷ 2.65)

pF = 6.24617 − (0.0723 X PM) if PM $\leq$ 54%

pF = 2.8948 − (0.01025 X PM) if PM > 54%

STRESS = 10^{pF}

AMC = (6.24617 X SM) ÷ (6.24617 − pF) if PF < 5.0

AMC = (10.0246 X SM) / (7 − pF) if pF $\geq$ 5.0

MRC = AMC X 0.625

SM (molecular layers of water) = (soil moisture ÷ MRC) X 10.0

VMC (molecular layers of water) = (VMC ÷ MRC) X 10

Vegetation cover measurements were made at each soil sampling site by the first-contact method. The first contact of a boot toe was recorded for 100 steps during a random walk through the associated vegetation type in the immediate area. Soils are normally sampled when soil moisture storage is at or near a minimum because of depletion by evapotranspiration. Hence, the soil moisture content at the time of sampling is designated minimum storage (MS). For each depth increment, the quantity of water that can be retained between MRC and MS and between VMC and MRC was computed as follows:

$$\left[(\text{MRC} - \text{MS}) \times \frac{\text{VW}}{100} \times \frac{\text{depth of increment in mm}}{1\ \text{g/cm}^3}\right] \quad \text{and}$$

$$\left[(\text{VMC} - \text{MRC}) \times \frac{\text{VW}}{100} \times \frac{\text{depth of increment in mm}}{1\ \text{g/cm}^3}\right]$$

The incremented values are summed to the depth of constrictions where MRC becomes less than MS and where VMC becomes less than MRC or to the base of the profile if constrictions are nonexistent. The resulting sums are profile values reported in depth-area millimeters of water, just as precipitation is reported in metric units.

The quantity of water that can be held in the profile between MRC and MS levels represents the normal annual maximum recharge or normal peak storage. The peak storage may occur over the fall, winter, and early spring from rain and snowmelt, or it may occur during a rainy period in the summer. Quantities of water added from precipitation events other than those that cause the peak storage are not included. The normal peak storage, therefore, is only an index of normal annual evapotranspiration.

The quantity of water that can be held in the profile between VMC and MRC levels is the amount of water that can be contained in remaining voids that are not filled at MRC. These voids may be partially or wholly filled following a precipitation event. In permeable soils, these voids will contain water only temporarily while drainage is occurring. In soils with drainage constrictions, these voids will contain water over a longer period, and that water would be held at retention forces less than $10^{2.34}$ g/cm^2, and thus be readily available to vegetation. An unusually wet period is required to fill all of the voids to VMC.

SECTION S

HYDROLOGY AND WATER SUPPLY APPENDIX

Table S-1. Summary of runoff volumes in and near the Kimbeto EMRIA study area.[1]

Streamflow gaging sites	Ah-shi-sle-pah Wash (in study area)	Hunter Wash (21 miles northwest of Kimbeto area)	De-na-zin Wash (14 miles northwest of Kimbeto area)	Chaco Wash (20 miles southeast of Kimbeto area)
Period of Record (years)	1977-78	1975-78	1976-78	1976-78
Drainage Area (mi^2)	8.2	45.6	184	578
Monthly average (runoff volume in acre-ft)				
October	61	19	99	48
November	174	88	173	3.7
December	28	18	6.8	8.7
January	36	9.2	3.7	.1
February	52	6.2	63	123
March	38	8.7	43	216
April	1.2	8.8	4.3	.4
May	175	43	1,618	190
June	4.1	1.8	0	0
July	242	110	240	639
August	106	157	350	698
September	82	166	294	228
Annual average (acre-ft)	999	636	2,895	2,155
Yield per square mile ($Acre\text{-}ft/mi^2/yr$)	122	13.9	15.7	3.73

[1]Runoff volumes in this table are preliminary and subject to revision.

Table S-2.--Summary of average monthly suspended-sediment discharge loads for Ah-shi-sle-pah, De-na-zin and Hunter Washes.[2]

Station	Ah-shi-sle-pah Wash	Hunter Wash	De-na-zin Wash
Period of Record (years)	1977-78	1975-78	1976-78
Drainage Area (mi^2)	8.2	45.6	184
Monthly Average (in tons)			
October	4,160	1,500	16,000
November	11,800	13,000	23,000
December	650	1,100	550
January	1,100	130	300
February	1,100	190	5,100
March	1,400	1,040	4,600
April	6	770	460
May	7,550	9,200	175,000
June	335	120	0
July	26,200	22,000	39,000
August	8,070	35,000	57,000
September	720	36,000	48,000
Annual Average in tons	63,091	120,050	369,010
Yield in acre-ft/mi^2/yr	3.5	1.2	0.92

[2] Suspended-sediment discharges in this table are preliminary and subject to revision.

Table S-3. Selected or average values of major chemical and physical parameters of surface waters in or near the Kimbeto EMRIA study area.

(analyses by the U.S. Geological Survey, Water Resources Division)

Column number this page	Descriptive Information
1....	Chaco Wash at Chaco Canyon National Monument, NM (USGS station no. 09367680) - average values
2....	Ah-shi-sle-pah Wash near Kimbeto, NM (USGS station no. 09367685) - average values
3....	Tsosie Swale near Kimbeto, NM (USGS site no. 36074310757410) - early spring storm runoff
4....	Escavado Wash at Highway 56 bridge near Chaco Canyon National Monument, NM (USGS site no. 360614107572010) - early spring storm runoff
5....	De-na-zin Wash near Bisti Trading Post, NM (USGS station no. 09367710) - average values
6....	Hunter Wash near Bisti Trading Post, NM (USGS station 09367930) - average values

Water quality major chemical and physical parameters

Row	Parameter	Code	Units	Column number this page 1	2	3	4	5	6	Row
1.	Date (Year-Month-Day) or years	-----	YMD	1976-1978	1977-1978	780507	1977-1978	1974-1978	1974-1978	1.
2.	Time (24 hour clock)	-----	HR-MIN	--	--	--	--	--	--	2.
3.	Water level below land surface datum	72019	feet	--	--	--	--	--	--	3.
4.	Depth to bottom of water bearing zone	72003	feet	--	--	--	--	--	--	4.
5.	Depth to top of water bearing zone	72002	feet	--	--	--	--	--	--	5.
6.	Discharge, instantaneous, stream	00061	cfs	78(266)*	100(30)*	5	30(2)*	212(52)*	45(148)*	6.
7.	Flow rate (yield of well)	00058	gpm	--	--	--	--	--	--	7.
8.	Specific conductance umhos/cm at 25°C	00095	umhos/cm	473(57)	882(21)	240	515(2)	708(32)	1120(59)	8.
9.	pH	00400	units	7.8(56)	7.6(21)	7.5	8.5(3)	7.8(25)	7.7(47)	9.
10.	Temperature, water	00010	°C	12.0(325)	11.0(12)	--	8.0(2)	17.5(18)	20.0(47)	10.
11.	Turbidity, in Jackson turbidity units	00070	JTU	16,000(3)	--	--	--	6,500(1)	4,300(3)	11.
12.	Dissolved oxygen (DO)	00300	mg/L	--	--	--	--	--	--	12.
13.	Chemical oxygen demand (COD)	00340	mg/L	407(3)	--	--	270(1)	89(1)	180(1)	13.
14.	Hardness as $CaCO_3$	00900	mg/L	74(22)	27(1)	25	8(2)	33(6)	72(21)	14.
15.	Noncarbonate hardness as $CaCO_3$	00902	mg/L	0(21)	0(1)	0	0	0(6)	16(21)	15.
16.	Calcium, dissolved as Ca	00915	mg/L	25(22)	9.5(1)	8.0	2.9(2)	12(6)	24(21)	16.
17.	Magnesium, dissolved as Mg	00925	mg/L	2.7(22)	0.8(1)	1.2	0.3(2)	0.9(6)	2.5(21)	17.
18.	Sodium, dissolved as Na	00930	mg/L	86(22)	180(1)	40	112(2)	127(6)	184(21)	18.
19.	Sodium-adsorption-ratio (SAR)	00931	----	5.3(22)	15(1)	3.5	17(2)	10(6)	11(21)	19.
20.	Potassium, dissolved as K	00935	mg/L	4.2(25)	4.4(1)	3.2	1.6(2)	2.7(6)	5.1(21)	20.
21.	Bicarbonate as HCO_3	00440	mg/L	211(24)	233(12)	104	220(2)	222(7)	173(21)	21.
22.	Carbonate as CO_3	00445	mg/L	0(20)	0(1)	0	0	0(7)	1(17)	22.
23.	Chloride, dissolved as Cl	00940	mg/L	7.7(23)	10(1)	4.4	2.7(2)	7.5(6)	11(20)	23.
24.	Sulfate, dissolved as SO_4	00945	mg/L	66(23)	250(1)	24	92(2)	123(6)	277(21)	24.
25.	Fluoride dissolved as F	00950	mg/L	0.8(23)	0.6(1)	0.6	1.0(2)	1.3(6)	1.0(21)	25.
26.	Silica, dissolved as SiO_2	00955	mg/L	11(23)	17(1)	9.4	14(2)	11(6)	20(21)	26.
27.	Dissolved solids, residue at 180°C	70300	mg/L	272(4)	--	--	--	--	--	27.
28.	Dissolved solids, calculated, sum	70301	mg/L	320(21)	581(1)	152	350(2)	404(6)	641(20)	28.
29.	Nitrite + Nitrate, total as N	00630	mg/L	1.8(10)	--	2.1	3.5(2)	2.6(3)	7.6(1)	29.
30.	Nitrite + Nitrate, dissolved as N	00631	mg/L	1.3(25)	7.7(1)	2.1	3.2(2)	2.2(6)	3.2(21)	30.
31.	Nitrogen, ammonia, total as N	00610	mg/L	0.02(7)	--	0.07	0.04(2)	0.01(2)	0.75(1)	31.
32.	Nitrogen, total organic as N	00605	mg/L	14(7)	--	3.5	12(2)	7.9(2)	7.4(1)	32.
33.	Phosphorus, total as P	00665	mg/L	2.1(11)	1.5(1)	0.31	1.2(2)	1.0(3)	0.17(1)	33.
34.	Phosphorus, dissolved PO_4 as P	00671	mg/L	0.06(25)	0.04(2)	0.02	0.40(2)	0.07(6)	0.96(11)	34.
35.	Boron, dissolved as B	01020	ug/L	73(29)	80(5)	60	130(2)	125(8)	154(28)	35.
36.	Iron, dissolved as Fe	01046	ug/L	115(33)	175(2)	50	270(2)	477(9)	1,580(18)	36.
37.	Carbon, organic total as C	00680	mg/L	122(43)	243(18)	--	64(2)	108(16)	188(20)	37.
38.	Carbon, organic dissolved as C	00681	mg/L	6.0(13)	6.9(6)	--	5.8(1)	5.0(4)	8.1(1)	38.
39.	Carbon, organic suspended as C	00689	mg/L	34(4)	83(3)	--	--	28(3)	--	39.
40.	Sediment, suspended, concentration	80154	mg/L	31,400(337)	54,800(51)	4020	34,600(2)	65,300(59)	48,700(134)	40.
41.	Sediment, suspended, sieve, % < 62.5 microns	70331	%	98(121)	81(45)	99	95(2)	93(55)	92(129)	41.
42.	Sulfide, total as S	00745	mg/L	--	--	--	--	--	--	42.

*Figures in parentheses are number of values averaged.

Table S-4. Selected or average values of trace element parameters for surface waters in or near the Kimbeto EMRIA study area.

(analyses by the U.S. Geological Survey, Water Resources Division)

Column number this page	Descriptive Information
1....	Chaco Wash at Chaco Canyon National Monument, NM (USGS station no. 09367680) - average values
2....	Ah-shi-sle-pah Wash near Kimbeto, NM (USGS station no. 09367685) - average values
3....	Tsosie Swale near Kimbeto, NM (USGS site no. 360743107571410) - early spring storm runoff
4....	Escavado Wash at Highway 56 bridge near Chaco Canyon National Monument, NM (USGS site no. 360614107572010) - early spring storm runoff
5....	De-na-zin Wash near Bisti Trading Post, NM (USGS station no. 09367710) - average values
6....	Hunter Wash near Bisti Trading Post, NM (USGS station no. 09367930) - average values

Water quality trace element parameters

Row	Parameter	Code	Units	Column number this page 1	2	3	4	5	6	Row
1.	Date (Year-Month-Day) or period in years	-----	YMD	1976-1978	1977-1978	780507	1977-1978	1974-1978	1974-1978	1.
2.	Time (24 Hour Clock)	-----	HR-MIN	--	--	--	--	--	--	2.
3.	Water level below land surface datum	72019	feet	--	--	--	--	--	--	3.
4.	Depth to bottom of water bearing zone	72003	feet	--	--	--	--	--	--	4.
5.	Depth to top of water bearing zone	72002	feet	--	--	--	--	--	--	5.
6.	Discharge, instantaneous, stream	00061	cfs	--	--	--	--	--	--	6.
7.	Flow rate (Yield of well)	00058	gpm	--	--	--	--	--	--	7.
8.	Specific conductance umhos/cm at 25°C	00095	umhos/cm	473(266)*	882(21)*	240	510(3)*	717(35)*	1119(59)*	8.
9.	pH	00400	units	7.7(57)	7.6(21)	7.5	8.5(3)	7.8(28)	7.7(47)	9.
10.	Arsenic, total as As	01002	ug/L	182(31)	180(16)	10	37.5(2)	105(11)	141(14)	10.
11.	Arsenic, dissolved as As	01000	ug/L	3(13)	1.2(5)	--	17.0(2)	3.0(3)	2.0(1)	11.
12.	Barium, total as Ba	01007	ug/L	4460(28)	1860(5)	--	5800(2)	3200(7)	3931(13)	12.
13.	Barium, dissolved as Ba	01005	ug/L	106(16)	125(4)	--	200(1)	60(5)	57(7)	13.
14.	Boron, total as B	01022	ug/L	191(29)	247(11)	--	--	179(7)	234(16)	14.
15.	Boron, dissolved as B	01020	ug/L	73(30)	80(5)	60	130(2)	122(10)	154(28)	15.
16.	Cadmium, total as Cd	01027	ug/L	7.0(25)	18.2(6)	--	16(2)	34(8)	12(10)	16.
17.	Cadmium, dissolved as Cd	01025	ug/L	0.6(12)	1.0(1)	--	2(1)	0.7(4)	1.0(1)	17.
18.	Chromium, total as Cr	01034	ug/L	139(27)	82.5(4)	--	125(2)	276(5)	290(10)	18.
19.	Chromium, dissolved as Cr	01030	ug/L	0.0(14)	3.3(3)	--	10(1)	5.0(4)	20.0(2)	19.
20.	Iron, total as Fe	01045	ug/L	158,000(13)	100,000(1)	--	--	196,666(3)	328,374(16)	20.
21.	Iron, dissolved as Fe	01046	ug/L	718(35)	175(2)	50	270(2)	412(12)	1581(18)	21.
22.	Lead, total as Pb	01051	ug/L	331(31)	547(8)	82	650(2)	528(5)	524(10)	22.
23.	Lead, dissolved as Pb	01049	ug/L	9.7(18)	16.0(2)	--	2(1)	7.6(5)	9.0(1)	23.
24.	Lithium, total as Li	01132	ug/L	193(14)	105(2)	--	--	137(3)	312(16)	24.
25.	Lithium, dissolved as Li	01130	ug/L	9.3(12)	20.0(2)	--	--	16.0(3)	29.2(13)	25.
26.	Manganese, total as Mn	01055	ug/L	4660(13)	1300(1)	--	--	3433(3)	13,981(15)	26.
27.	Manganese, dissolved as Mn	01056	ug/L	652(15)	10(1)	--	--	8.0(5)	137(7)	27.
28.	Mercury, total as Hg	71900	ug/L	0.98(17)	1.6(13)	0.4	0.65(2)	2.0(12)	2.0(14)	28.
29.	Mercury, dissolved as Hg	71890	ug/L	0.02(11)	0.02(5)	--	--	0.0(2)	0.0(1)	29.
30.	Selenium, total as Se	01147	ug/L	4.0(20)	7.4(14)	--	--	2.9(11)	1.6(14)	30.
31.	Selenium, dissolved as Se	01145	ug/L	0.9(10)	0.25(4)	--	3.0(1)	2.0(3)	5.0(1)	31.
32.	Strontium, total as Sr	01082	ug/L	3096(10)	2000(2)	--	--	3050(4)	5408(12)	32.
33.	Strontium, dissolved as Sr	01080	ug/L	219(9)	215(2)	--	--	247(4)	745(6)	33.
34.	Alpha, gross dissolved as U natural	80030	ug/L	9.0(6)	6.2(1)	--	--	18.0(1)	46.0(2)	34.
35.	Alpha, gross suspended as U natural	80040	ug/L	2466(6)	880(1)	--	--	720(1)	1285(2)	35.
36.	Beta, gross dissolved as Cs-137	03515	pCi/L	6.1(6)	14.0(1)	--	--	4.1(1)	17.2(2)	36.
37.	Beta, gross suspended as Cs-137	03516	pCi/L	748(6)	420(1)	--	--	320(1)	495(2)	37.
38.	Beta, gross dissolved as strontium/yttrium-90	80050	pCi/L	5.1(6)	12.0(1)	--	--	3.7(1)	14.0(2)	38.
39.	Beta, gross suspended as strontium/yttrium-90	80060	pCi/L	619(6)	370(1)	--	--	290(1)	400(2)	39.
40.	Radium-226, dissolved, radon method	09511	pCi/L	0.1(6)	0.06(1)	--	--	0.18(1)	0.13(2)	40.
41.	Uranium, dissolved, as U	80010	ug/L	2.9(1)	--	--	--	--	3.4(1)	41.

*Figure in parentheses are number of values averaged.

Table S-5. Values of major chemical and physical parameters in ground waters within or near the Kimbeto study area.

(analyses by the U.S. Geological Survey, Water Resources Division)

Column number this page	Descriptive Information
1....	DH1K Kimbeto Pictured Cliff Formation Well near Kimbeto, NM (360822 107561601) (22N.10W.18.411)
2....	DH2K Kimbeto Fruitland Formation Coal Well near Kimbeto, NM (360849 107561801) (22N.10W.18.211)
3....	DH3K Kimbeto overburden well near Kimbeto, NM (360941 1075616) (22N.10W.07.211)
4....	DH4K Kimbeto Fruitland Formation Coal Well near Kimbeto, NM (360823 107544001) (22N.10W.17.422)
5....	DH5K Kimbeto Pictured Cliff Formation Well near Kimbeto, NM (360916 107543901) 22N.10W.08.244)
6....	DH6K Kimbeto Fruitland Formation Coal Well near Kimbeto, NM (361008 107543901) (22N.10W.04.133)

Water quality major chemical and physical parameters

Row	Parameter	Code	Units	Column number this page 1	2	3	4	5	6	Row
1.	Date (Year-Month-Day)	-----	YMD	780223	780224	770816	780524	780224	780524	1.
2.	Time (24 hour clock)	-----	HR-MIN	1400	0930	1300	1530	1145	1200	2.
3.	Water level below land surface datum	72019	feet	94.5	90.7	27.8	115	138	69.4	3.
4.	Depth to bottom of water bearing zone	72003	feet	285.0	205.0	80.0	190	474.0	290.0	4.
5.	Depth to top of water bearing zone	72002	feet	180.0	91.0	40.0	160	355.0	205.0	5.
6.	Discharge, instantaneous, stream	00061	cfs	--	--	--	--	--	--	6.
7.	Flow rate (yield of well)	00058	gpm	swabbed	swabbed	air lifted	swabbed	swabbed	swabbed	7.
8.	Specific conductance umhos/cm at 25°C	00095	umhos/cm	3100	4200	18000	3800	14500	13000	8.
9.	pH	00400	units	9.3	8.0	12.4	9.1	7.9	7.7	9.
10.	Temperature, water	00010	°C	15.5	14.0	21.0	15.0	15.5	16.0	10.
11.	Turbidity, in Jackson turbidity units	00070	JTU	--	--	--	--	--	--	11.
12.	Dissolved oxygen (DO)	00300	mg/L	--	--	--	--	--	--	12.
13.	Chemical oxygen demand (COD)	00340	mg/L	--	--	--	42	--	180	13.
14.	Hardness as $CaCO_3$	00900	mg/L	16	45	510	29	170	260	14.
15.	Noncarbonate hardness as $CaCO_3$	00902	mg/L	0	0	510	0	0	0	15.
16.	Calcium, dissolved as Ca	00915	mg/L	4.9	14	200	9.1	40	99	16.
17.	Magnesium, dissolved as Mg	00925	mg/L	0.8	2.2	0.1	1.5	15	1.8	17.
18.	Sodium, dissolved as Na	00930	mg/L	800	1000	2500	960	3100	3300	18.
19.	Sodium-adsorption-ratio (SAR)	00931	----	88	66	49	78	106	90	19.
20.	Potassium, dissolved as K	00935	mg/L	3.6	4.3	98	9.7	14	14	20.
21.	Bicarbonate as HCO_3	00440	mg/L	992	2060	0	1560	720	712	21.
22.	Carbonate as CO_3	00445	mg/L	181	0	0	191	0	0	22.
23.	Chloride, dissolved as Cl	00940	mg/L	230	470	2700	270	4400	4700	23.
24.	Sulfate, dissolved as SO_4	00945	mg/L	280	24	38	130	100	16	24.
25.	Fluoride dissolved as F	00950	mg/L	4.3	2.2	1.2	1.7	1.3	0.8	25.
26.	Silica, dissolved as SiO_2	00955	mg/L	10	11	2.6	16	9.4	10	26.
27.	Dissolved solids, residue at 180°C	70300	mg/L	--	--	--	--	--	6590	27.
28.	Dissolved solids, calculated, sum	70301	mg/L	2010	2540	6350	2370	8040	8500	28.
29.	Nitrite + Nitrate, total as N	00630	mg/L	--	--	--	--	--	--	29.
30.	Nitrite + Nitrate, dissolved as N	00631	mg/L	0.04	0.02	0.23	1.6	0.04	0.04	30.
31.	Nitrogen, ammonia, total as N	00610	mg/L	--	--	--	--	--	--	31.
32.	Nitrogen, total organic as N	00605	mg/L	--	--	--	--	--	--	32.
33.	Phosphorus, total as P	00665	mg/L	--	--	--	--	--	--	33.
34.	Phosphorus, dissolved PO_4 as P	00671	mg/L	0.05	0.01	0.01	2.7	0.01	0.03	34.
35.	Boron, dissolved as B	01020	ug/L	600	620	--	580	620	670	35.
36.	Iron, dissolved as Fe	01046	ug/L	80	30	20	0	20	20	36.
37.	Carbon, organic total as C	00680	mg/L	--	--	--	--	--	--	37.
38.	Carbon, organic dissolved as C	00681	mg/L	18	14	19	14	6.8	7.1	38.
39.	Carbon, organic suspended as C	00689	mg/L	--	--	--	0.5	--	--	39.
40.	Sediment, suspended, concentration	80154	mg/L	--	--	--	--	--	--	40.
41.	Sediment, suspended, sieve, % < 62.5 microns...	70331	%	--	--	--	--	--	--	41.
42.	Sulfide, total as S	00745	mg/L	1.0	13	--	0.2	0.5	0.2	42.

Table S-6. Values of trace element parameters in ground waters within or near the Kimbeto study area.

Column number this page	Descriptive Information
1....	DH1K Kimbeto Pictured Cliff Formation Well near Kimbeto, NM (360822 107561601) (22N.10W.18.411)
2....	DH2K Kimbeto Fruitland Formation Coal Well near Kimbeto, NM (360849 107561801) (22N.10W.18.211)
3....	DH3K Kimbeto overburden well near Kimbeto, NM (360941 1075616) (22N.10W.07.211)
4....	DH4K Kimbeto Fruitland Formation Coal Well near Kimbeto, NM (360823 107544001) (22N.10W.17.422)
5....	DH5K Kimbeto Pictured Cliff Formation Well near Kimbeto, NM (360916 107543901) (22N.10W.08.244)
6....	DH6K Kimbeto Fruitland Formation Coal Well near Kimbeto, NM (361008 107543901) (22N.10W.04.133)

Water quality trace element parameters

Row	Parameter	Code	Units	Column number this page 1[a]	2[b]	3[c]	4[d]	5[e]	6[f]	Row
1.	Date (Year-Month-Day)	-----	YMD	780223	780224	770816	780524	780224	780524	1.
2.	Time (24 Hour Clock)	-----	HR-MIN	1400	0930	1300	1530	1145	1200	2.
3.	Water level below land surface datum	72019	feet	94.5	90.7	27.8	115	138	69.4	3.
4.	Depth to bottom of water bearing zone	72003	feet	285.0	205.0	80.0	190	474.0	290.0	4.
5.	Depth to top of water bearing zone	72002	feet	180.0	91.0	40.0	160	355.0	205.0	5.
6.	Discharge, instantaneous, stream	00061	cfs	--	--	--	--	--	--	6.
7.	Flow rate (Yield of well)	00058	gpm	swabbed	swabbed	air lifted	swabbed	swabbed	swabbed	7.
8.	Specific conductance umhos/cm at 25°C	00095	umhos/cm	3100	4200	18000	3800	14500	13000	8.
9.	pH	00400	units	9.3	8.0	12.4	9.1	7.9	7.7	9.
10.	Arsenic, total as As	01002	ug/L	--	--	--	--	--	--	10.
11.	Arsenic, dissolved as As	01000	ug/L	1	1	0	10	0	1	11.
12.	Barium, total as Ba	01007	ug/L	--	--	--	--	--	--	12.
13.	Barium, dissolved as Ba	01005	ug/L	0	200	700	200	1300	3400	13.
14.	Boron, total as B	01022	ug/L	--	--	--	--	--	--	14.
15.	Boron, dissolved as B	01020	ug/L	600	620	30	580	620	670	15.
16.	Cadmium, total as Cd	01027	ug/L	--	--	--	--	--	--	16.
17.	Cadmium, dissolved as Cd	01025	ug/L	1	1	1	1	1	2	17.
18.	Chromium, total as Cr	01034	ug/L	--	--	--	--	--	--	18.
19.	Chromium, dissolved as Cr	01030	ug/L	60	10	80	5	10	0	19.
20.	Iron, total as Fe	01045	ug/L	--	--	--	--	--	--	20.
21.	Iron, dissolved as Fe	01046	ug/L	80	30	20	0	20	20	21.
22.	Lead, total as Pb	01051	ug/L	--	--	--	--	--	--	22.
23.	Lead, dissolved as Pb	01049	ug/L	6	0	4	20	0	15	23.
24.	Lithium, total as Li	01132	ug/L	--	--	--	--	--	--	24.
25.	Lithium, dissolved as Li	01130	ug/L	80	90	230	90	290	240	25.
26.	Manganese, total as Mn	01055	ug/L	--	--	--	--	--	--	26.
27.	Manganese, dissolved as Mn	01056	ug/L	0	20	0	10	50	80	27.
28.	Mercury, total as Hg	71900	ug/L	--	--	--	--	--	--	28.
29.	Mercury, dissolved as Hg	71890	ug/L	0.0	0.0	--	0.0	0.0	0.0	29.
30.	Selenium, total as Se	01147	ug/L	--	--	--	--	--	--	30.
31.	Selenium, dissolved as Se	01145	ug/L	0	0	9	0	0	0	31.
32.	Strontium, total as Sr	01082	ug/L	--	--	--	--	--	--	32.
33.	Strontium, dissolved as Sr	01080	ug/L	150	430	9400	240	2200	3300	33.
34.	Alpha, gross dissolved as U natural	80030	ug/L	--	--	--	--	--	220	34.
35.	Alpha, gross suspended as U natural	80040	ug/L	--	--	--	--	--	--	35.
36.	Beta, gross dissolved as Cs-137	03515	pCi/L	--	--	--	--	--	44	36.
37.	Beta, gross suspended as Cs-137	03516	pCi/L	--	--	--	--	--	--	37.
38.	Beta, gross dissolved as strontium/yttrium-90	80050	pCi/L	--	--	--	--	--	40	38.
39.	Beta, gross suspended as strontium/yttrium-90	80060	pCi/L	--	--	--	--	--	--	39.
40.	Radium-226, dissolved, radon method	09511	pCi/L	<0.1	0.6	0.7	0.2	3.8	7.3	40.
41.	Uranium, dissolved, as U	80010	ug/L	1.4	<0.4	<0.4	1.2	< 0.4	<0.4	41.

a) Other dissolved values in ug/l: Co, 0; Cu, 2.
b) Other dissolved values in ug/l: Co, 0; Cu, 2.
c) Other dissolved values in ug/l: Co, 0; Cu, 6.
d) Other dissolved values in ug/l: Al, 10; Be, 0; Co, 0; Mo, 0; Ni, 0; Ag, 0; V, 2.0; Zn, 30.
e) Other dissolved values in ug/l: Co, 0; Cu, 0.
f) Other dissolved values in ug/L: Al, 2; Be, 5; Cu, 1; Mo, 0; Ni, 0; Ag, 0; V, 63; Zn, 440.

Table S-7. Values of major chemical and physical parameters in ground waters within or near the Kimbeto study area.

Column number this page	Descriptive Information
1....	DH7K Kimbeto Fruitland Formation Coal Well near Kimbeto, NM (360734 107523101) (22N.10W.22.244)
2....	DH8K Kimbeto overburden well near Kimbeto, NM (360857 107531001) (22N.10W.10.341)
3....	DH9K Kimbeto overburden well near Kimbeto, NM (360754 107505201) (22N.10W.24.211)
4....	DH10K Kimbeto Pictured Cliff Formation Well near Kimbeto, NM (360731 107494701) (22N.09W.19.144)
5....	Ground water from channel alluvium
6....	Ground water from the Morrison Formation

Water quality major chemical and physical parameters

Row	Parameter	Code	Units	Column number this page 1	2	3	4	5	6	Row
1.	Date (Year-Month-Day)	-----	YMD	771116	770818	771116	780522	1973-1978	1973-1978	1.
2.	Time (24 hour clock)	-----	HR-MIN	1245	1750	0930	1100	--	--	2.
3.	Water level below land surface datum	72019	feet	92.0	16.2	--	155	--	--	3.
4.	Depth to bottom of water bearing zone	72003	feet	185.0	--	130.0	483.0	--	--	4.
5.	Depth to top of water bearing zone	72002	feet	145.0	--	70.0	349.0	--	--	5.
6.	Discharge, instantaneous, stream	00061	cfs	--	--	--	--	--	--	6.
7.	Flow rate (yield of well)	00058	gpm	air lifted	air lifted	air lifted	swabbed	--	--	7.
8.	Specific conductance umhos/cm at 25°C	00095	umhos/cm	2900	17000	1250	11000	2020 (63)*	3240 (4)*	8.
9.	pH	00400	units	9.9	12.7	9.0	8.5	7.9 (61)	8.5 (2)	9.
10.	Temperature, water	00010	°C	14.5	19.0	13.0	15.0	12.5 (55)	51 (4)	10.
11.	Turbidity, in Jackson turbidity units	00070	JTU	--	--	--	--	--	--	11.
12.	Dissolved oxygen (DO)	00300	mg/L	--	--	--	--	1.2 (18)	--	12.
13.	Chemical oxygen demand (COD)	00340	mg/L	--	--	--	150	24 (1)	--	13.
14.	Hardness as $CaCO_3$	00900	mg/L	5	830	11	70	302 (60)	471 (4)	14.
15.	Noncarbonate hardness as $CaCO_3$	00902	mg/L	0	510	0	0	124 (60)	397 (4)	15.
16.	Calcium, dissolved as Ca	00915	mg/L	1.7	320	3.8	19	83 (60)	182 (4)	16.
17.	Magnesium, dissolved as Mg	00925	mg/L	0.2	0.1	0.4	5.2	23 (60)	3.8 (4)	17.
18.	Sodium, dissolved as Na	00930	mg/L	720	1200	310	2500	391 (60)	630 (4)	18.
19.	Sodium-adsorption-ratio (SAR)	00931	----	139	18	40	131	10.8 (60)	19 (4)	19.
20.	Potassium, dissolved as K	00935	mg/L	5.6	470	2.5	13	4.0 (60)	6.8 (4)	20.
21.	Bicarbonate as HCO_3	00440	mg/L	950	0	510	508	401 (60)	229 (4)	21.
22.	Carbonate as CO_3	00445	mg/L	510	190	45	10	1 (51)	6 (2)	22.
23.	Chloride, dissolved as Cl	00940	mg/L	62	120	8.7	3800	16 (60)	25 (4)	23.
24.	Sulfate, dissolved as SO_4	00945	mg/L	200	24	200	98	770 (60)	1530 (4)	24.
25.	Fluoride dissolved as F	00950	mg/L	3.0	1.0	2.2	1.6	1.0 (60)	3.3 (4)	25.
26.	Silica, dissolved as SiO_2	00955	mg/L	24	0.4	12	30	13 (60)	28 (4)	26.
27.	Dissolved solids, residue at 180°C	70300	mg/L	--	--	--	5670	--	--	27.
28.	Dissolved solids, calculated, sum	70301	mg/L	2000	3550	838	6740	1510 (60)	2530 (4)	28.
29.	Nitrite + Nitrate, total as N	00630	mg/L	--	--	--	--	--	0.01 (1)	29.
30.	Nitrite + Nitrate, dissolved as N	00631	mg/L	0.11	0.17	0.35	2.0	1.6 (42)	0.02 (2)	30.
31.	Nitrogen, ammonia, total as N	00610	mg/L	--	--	--	--	0.2 (19)	0.4 (1)	31.
32.	Nitrogen, total organic as N	00605	mg/L	--	--	--	--	0.4 (19)	0.2 (2)	32.
33.	Phosphorus, total as P	00665	mg/L	--	--	--	0.48	0.1 (19)	0.03 (1)	33.
34.	Phosphorus, dissolved PO_4 as P	00671	mg/L	0.10	0.00	0.04	0.48	0.02 (42)	0.05 (4)	34.
35.	Boron, dissolved as B	01020	ug/L	470	--	--	730	98 (60)	180 (1)	35.
36.	Iron, dissolved as Fe	01046	ug/L	110	10	190	10	497 (60)	50 (4)	36.
37.	Carbon, organic total as C	00680	mg/L	--	--	--	--	--	--	37.
38.	Carbon, organic dissolved as C	00681	mg/L	9.4	53	4.5	8.9	4.7 (15)	0.7 (1)	38.
39.	Carbon, organic suspended as C	00689	mg/L	--	--	--	--	--	--	39.
40.	Sediment, suspended, concentration	80154	mg/L	--	--	--	--	--	--	40.
41.	Sediment, suspended, sieve, % < 62.5 microns...	70331	%	--	--	--	--	--	--	41.
42.	Sulfide, total as S	00745	mg/L	0.0	--	0.0	0.2	0.2 (11)	0.0 (1)	42.

*Figure in parentheses are number of values averaged.

Table S-8. Values of trace element parameters in ground waters within or near the Kimbeto study area.

Column number this page	Descriptive Information
1....	DH7K Kimbeto Fruitland Formation Coal Well near Kimbeto, NM (360734 107523101) (22N.10W.22.244)
2....	DH8K Kimbeto overburden well near Kimbeto, NM (360857 107531001) (22N.10W.10.341)
3....	DH9K Kimbeto overburden well near Kimbeto, NM (360754 107505201) (22N.10W.24.211)
4....	DH10K Kimbeto Pictured Cliff Formation Well near Kimbeto, NM (360731 107494701) (22N.09W.19.144)
5....	Ground water from channel alluvium
6....	Ground water from the Morrison Formation

Water quality trace element parameters

Row	Parameter	Code	Units	Column number this page 1[a]	2[b]	3[c]	4[d]	5	6	Row
1.	Date (Year-Month-Day)	-----	YMD	771116	770818	771116	780522	1973-1978	1973-1978	1.
2.	Time (24 Hour Clock)	-----	HR-MIN	1245	1750	0930	1100	--	--	2.
3.	Water level below land surface datum	72019	feet	92.0	16.2	--	155	--	--	3.
4.	Depth to bottom of water bearing zone	72003	feet	185.0	--	130.0	483.0	--	--	4.
5.	Depth to top of water bearing zone	72002	feet	145.0	--	70.0	349	--	--	5.
6.	Discharge, instantaneous, stream	00061	cfs	--	--	--	--	--	--	6.
7.	Flow rate (Yield of well)	00058	gpm	air lifted	air lifted	air lifted	swabbed	--	--	7.
8.	Specific conductance umhos/cm at 25°C	00095	umhos/cm	2900	17000	1250	11000	2020(63)*	3240(4)*	8.
9.	pH	00400	units	9.9	12.7	9.0	8.5	7.9(61)	8.5(2)	9.
10.	Arsenic, total as As	01002	ug/L	--	--	--	--	--	--	10.
11.	Arsenic, dissolved as As	01000	ug/L	1	0	14	6	1.4(19)	5.0(1)	11.
12.	Barium, total as Ba	01007	ug/L	--	--	--	--	--	--	12.
13.	Barium, dissolved as Ba	01005	ug/L	0	3000	0	200	63(19)	--	13.
14.	Boron, total as B	01022	ug/L	--	--	--	--	--	--	14.
15.	Boron, dissolved as B	01020	ug/L	470	4	330	730	98(60)	180(1)	15.
16.	Cadmium, total as Cd	01027	ug/L	--	--	--	--	--	--	16.
17.	Cadmium, dissolved as Cd	01025	ug/L	0	0	3	4	2.3(20)	0.0(1)	17.
18.	Chromium, total as Cr	01034	ug/L	--	--	--	--	--	--	18.
19.	Chromium, dissolved as Cr	01030	ug/L	8	0	8	0	2.5(20)	0.0(1)	19.
20.	Iron, total as Fe	01045	ug/L	--	--	--	--	--	--	20.
21.	Iron, dissolved as Fe	01046	ug/L	110	10	190	10	497(61)	50(4)	21.
22.	Lead, total as Pb	01051	ug/L	--	--	--	--	--	--	22.
23.	Lead, dissolved as Pb	01049	ug/L	7	14	11	51	9.2(20)	0.0(1)	23.
24.	Lithium, total as Li	01132	ug/L	--	--	--	--	--	--	24.
25.	Lithium, dissolved as Li	01130	ug/L	60	1700	30	240	42(37)	360(2)	25.
26.	Manganese, total as Mn	01055	ug/L	--	--	--	--	--	--	26.
27.	Manganese, dissolved as Mn	01056	ug/L	0	20	0	5	718(21)	177(4)	27.
28.	Mercury, total as Hg	71900	ug/L	--	--	--	--	--	--	28.
29.	Mercury, dissolved as Hg	71890	ug/L	--	--	--	0.1	0.00(19)	0.10(1)	29.
30.	Selenium, total as Se	01147	ug/L	--	--	--	--	--	--	30.
31.	Selenium, dissolved as Se	01145	ug/L	1	1	1	0	1.6(19)	0.0(1)	31.
32.	Strontium, total as Sr	01082	ug/L	--	--	--	--	--	--	32.
33.	Strontium, dissolved as Sr	01080	ug/L	80	23000	100	1200	520(1)	--	33.
34.	Alpha, gross dissolved as U natural	80030	ug/L	--	--	--	54	27(19)	84(1)	34.
35.	Alpha, gross suspended as U natural	80040	ug/L	--	--	--	--	--	--	35.
36.	Beta, gross dissolved as Cs-137	03515	pCi/L	--	--	--	25	8.4(19)	88(1)	36.
37.	Beta, gross suspended as Cs-137	03516	pCi/L	--	--	--	--	--	--	37.
38.	Beta, gross dissolved as strontium/yttrium-90	80050	pCi/L	--	--	--	24	13(1)	80(1)	38.
39.	Beta, gross suspended as strontium/yttrium-90	80060	pCi/L	--	14	--	--	--	--	39.
40.	Radium-226, dissolved, radon method	09511	pCi/L	0.2	--	0.2	0.5	0.07(1)	1.6(1)	40.
41.	Uranium, dissolved, as U	80010	ug/L	0.9	< 0.4	4.6	2.3	9.8(1) 0.0(1)	--	41.

a) Other dissolved values in ug/l: Co, 0; Cu, 6.

b) Other dissolved values in ug/l: Co, 0; Cu, 2.

c) Other dissolved values in ug/l: Cu, 12.

d) Other dissolved values in ug/l: Al, 50; Be, 0; Cu, 3; Mo, 6; Ni, 0; Ag, 0; V, 51; Zn, 30.

*Figure in parentheses are number of values averaged.

Table S-9

Summary of pertinent provisions of water-quality regulations with respect to mining at the Kimbeto study area

A. New Mexico State Water Quality Standards for Interstate and Intrastate Streams (as adopted by the New Mexico Water Quality Control Commission under the New Mexico Water Quality Act, Chapter 326, Laws of 1973, as amended).

These standards will permit the lowering of the quality of surface water below that which naturally exists providing that such changes are justified for social or economic development and will not interfere with or become injurious to any assigned or potential uses of the water. Designated uses for the part of the San Juan River that includes the Chaco River system are industrial water supply, irrigation, livestock and wildlife watering, secondary contact recreation, and warm water fishery.

General standard of these regulations state that surface waters should be virutally free of, or at the most, contain environmentally harmless or undamaging levels of radicactivity, pathogenic bacteria, turbidity, stream bottom deposits, floating solids, oils and greases, color, odor, plant nutrients, pesticides, herbicides, heavy metals, and toxic organic compounds.

Specific standards that would apply for the part of the San Juan River system that includes the Chaco River system area are: Dissolved oxygen, greater than 5 mg/L; pH, within the range 6.6 and 8.6; temperature, less than 32.2 C; and fecal coliform bacteria, less than 100 counts per 100 ml.

Numerical standards for salinity have not been adopted for this part of the San Juan Basin; however, the State of New Mexico is cooperating with the other Colorado River Basin states and the Federal Government to support and implement salinity control policies and programs including any that are related to coal mining.

B. New Mexico State Water Quality Control Commission Regulations for discharges onto or below the surface of the ground (authorized under the New Mexico Water Quality Act, Chapter 326, as amended January 11, 1977).

The purpose of these regulations is to protect ground water supplies with dissolved solids concentration of 10,000 mg/L or less for present or future use and to protect segments of surface waters which gain from ground water inflow for uses designated in the New Mexico Water Quality Standards.

Table S-9.--cont'd.

Degradation of ground water up to the limit of the standard (see tables below) is allowed, and if a ground water supply naturally exceeds the limits of the standards, degradation beyond the natural levels is not allowed.

The standards are not intended as maximum concentrations for use but as protective limits for ground water supplies.

These regulations do not apply to any discharges into interstate or navigable streams which are subject to a permit under the National Pollution Discharge Elimination System (NPDES) of the Federal Water Pollution Control Act, PL 92-500.

Human Health

Arsenic, ug/L	100	Silver, ug/L	50
Barium, ug/L	1000	Uranium, ug/L	5000
Cadmium, ug/L	10	Radioactivity, pCi/L	30
Chromium, ug/L	50	Cyanide, mg/L	0.2
Lead, ug/L	50	Flouride, mg/L	1.6
Total Mercury, ug/L	2	Nitrate as N, mg/L	10
Selenium, ug/L	50		

Domestic Supply

Chloride, mg/L	250	Sulfate, mg/L	600
Copper, ug/L	1000	Dissolved solids, mg/L	1000
Iron, ug/L	1000	Zinc, ug/L	10000
Manganese, ug/L	200	pH	6 to 9
Phenols, ug/L	5		

Irrigation

Aluminum, ug/L	5000	Molybdenum, ug/L	1000
Boron, ug/L	750	Nickel, ug/L	200
Cobalt, ug/L	50		

C. Federal Water Pollution Control Act (FWPCA) Amendments of 1972 (86 Stat. 816 et seq., Public Law 92-500, 33 U.S.C. 1251 et seq. - Section 402 and Section 208).

The FWPCA establishes two different regulation systems to control water pollution under Section 402 and Section 208 of the Act which are both administered by the EPA.

Section 402 is referred to as the National Pollutant Discharge Elimination Section (NPDES). The primary objective of this section is the regulation of pollution from industrial point sources and municipal treatment plants which discharge wastewater directly or indirectly into interstate or navigable streams. Anyone discharging water that may affect the water quality of such streams must apply for a permit from EPA. The intent of the regulation is to limit pollution through a permit system and within a permit system numerical limits may be specified.

Section 208 is referred to as the State - Regional area-wide waste treatment management system which leaves the development of non-structural control measures and land use practices to control water pollution to State and Regional agencies. This regulation is directed at diffuse (non-point) source pollution that drain or runoff, directly or indirectly, into interstate or navigable streams. Statewide general management plans are being developed including one for sediment control. These plans, however, do not specifically address coal mining activities, but future plans may.

D. Federal Office of Surface Mining Reclamation and Enforcement permanent regulatory program (Federal Register March 15, 1979, Vol. 44, No. 50, Part II, pages 15411-15463 as required by title V of the Federal Surface Mining Control and Reclamation Act of 1977, Public Law 95-87, U.S.C. 1201, 91 stat. 445).

The following statements are water quality related provisions abstracted from the proposed mining regulations:

Surface mining permit applicants are required to furnish information on the environmental resources, including the quantity and quality of surface water (SW) and ground water (GW) supplies within and adjacent to the permit area. The regulatory agency is to furnish information on the surrounding or adjacent area from Federal or other sources if available, otherwise this gathering of information is the responsibility of the applicant (Subchapter G, part 779).

The applicant is to include in a reclamation plan, measures to be taken during and after mining to insure the protection of the quality of the surface and ground water systems within and adjacent to the proposed mine. The reclamation plan is to include a water quality monitoring plan of discharges form the proposed mine and a description of probable hydrologic consequence of the proposed mine to include anticipated changes in dissolved solids, suspended solids, iron content, manganese content, and pH of the water (Subchapter G, part 780).

Table S-9.--cont'd.

These regulations will not permit surface coal mining on alluvial valley floors in the western United States if this mining will damage the quantity and quality of the water supply downstream for existing, or potentially, economical, important farming operations. (Subchapter K, part 822).

Minimum performance standards for mining and reclamation are set forth to minimize disturbance to the prevailing hydrologic balance including changes to the quality and quantity of SW and GW supplies. Any practices should comply with the most stringent of applicable State or Federal regulations. (Subchapter K, parts 816.41 to 816.57, inclusive).

These regulations proposed the following limits on effluent from the mining and reclamation area (subchapter K, part 816.42):

Iron, total	7000 ug/L maximum allowable
Manganese, total	4000 ug/L maximum allowable
Suspended solids	45 mg/L maximum allowable
pH	within range of 6.0 to 9.0

E. National Interim Primary Drinking Water Regulations (pursuant to the section 1412 of the Public Health Service Act, Pl 93 523, 40 FR 11990).

These regulations apply to any water supply system that supplies piped water for human consumption to at least 25 individuals for at least 60 days per year.

These regulations are administered by the EPA and replace the U.S. Public Health Service Drinking Water Standards of 1962.

Maximum contaminant levels (MCL) that have been established under these regulations are:

Arsenic, ug/L	50	Radium-226 plus Radium-228, pCi/L	5
Barium, ug/L	1000	Gross alpha, pCi/L (includes Ra but excludes Rd and U)	15
Cadmium, ug/L	10		
Chromium, ug/L	50		
Lead, ug/L	50		
Mercury, ug/L	2	Turbidity (in turbidity units)	1
Selenium, ug/L	10		
Silver, ug/L	50	Coliform bacteria (counts/100 ml, monthly average)	1
Nitrate as N, mg/L	10		
Flouride, mg/L	1.8*		

*The annual average maximum daily air temperature for a location determines the flouride MCL. This value is for a maximum daily air temperature range between 63.9 F to 70.6 F.

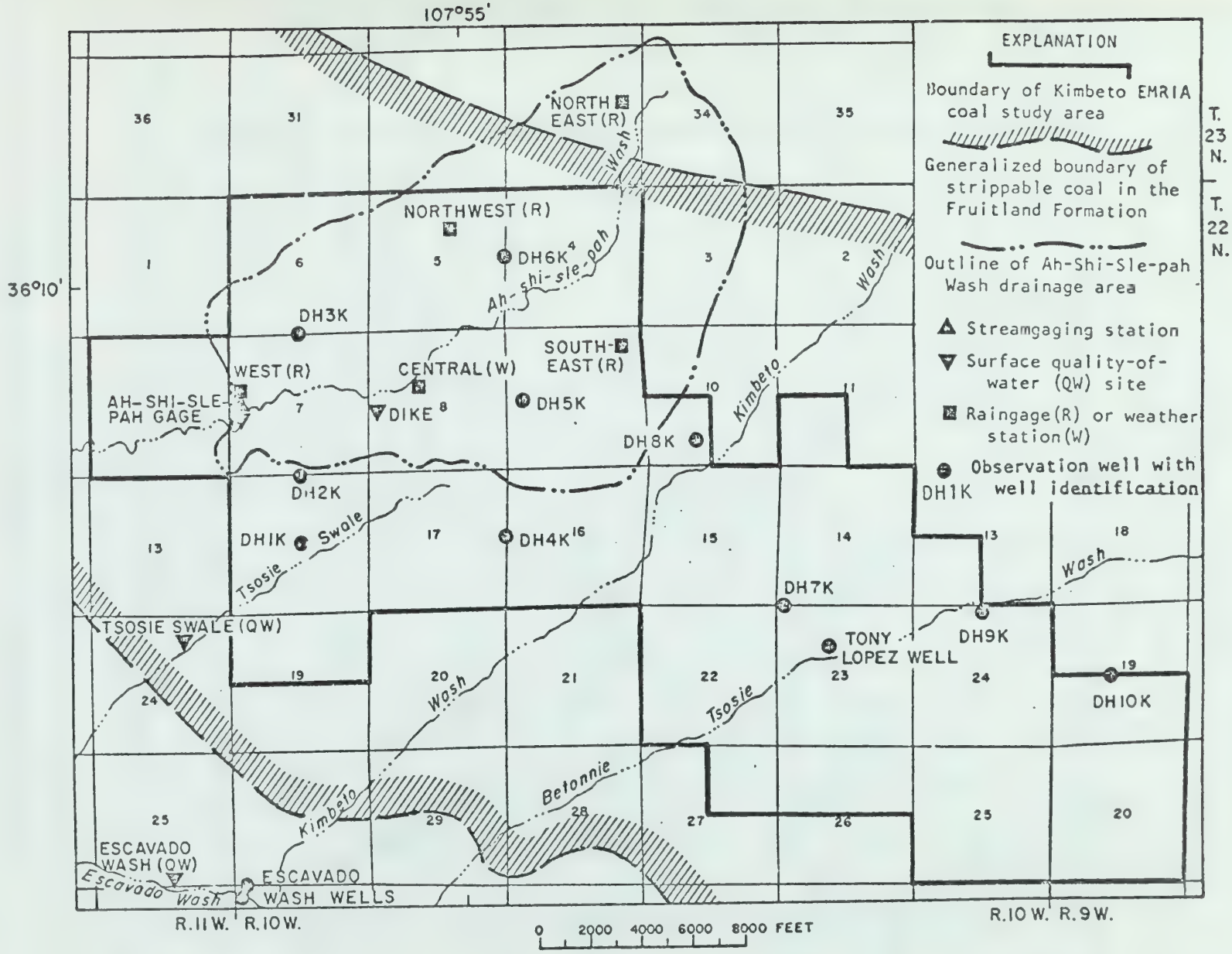


Figure S-1. --Hydrologic data collection sites in the Kimbeto EMRIA coal study area, northwestern New Mexico

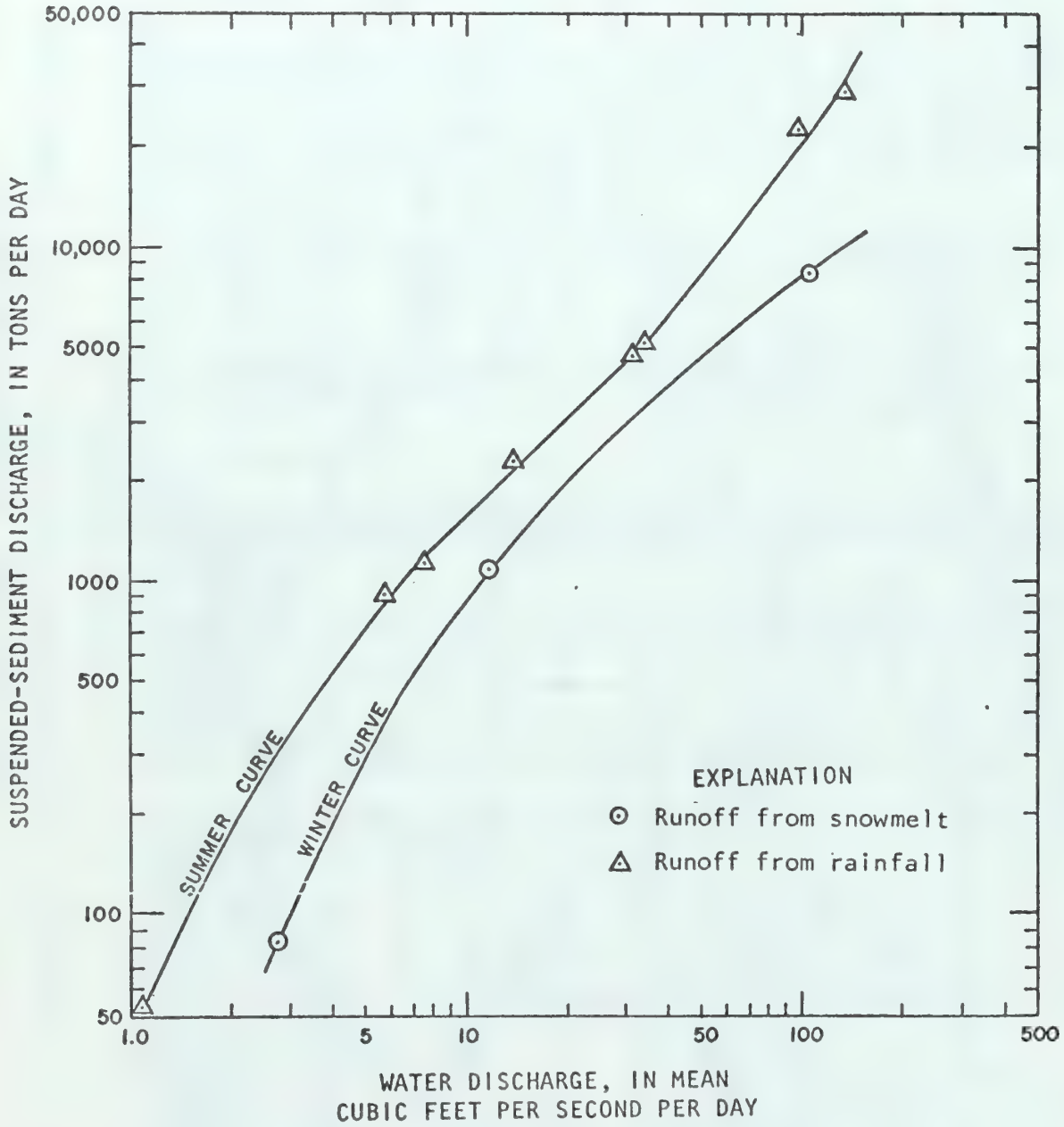


Figure 5-2 --Relationship between daily suspended-sediment discharge and water discharge, Ah-shi-sle-pah Wash at Kimbeto EMRIA study area, 1977-78.

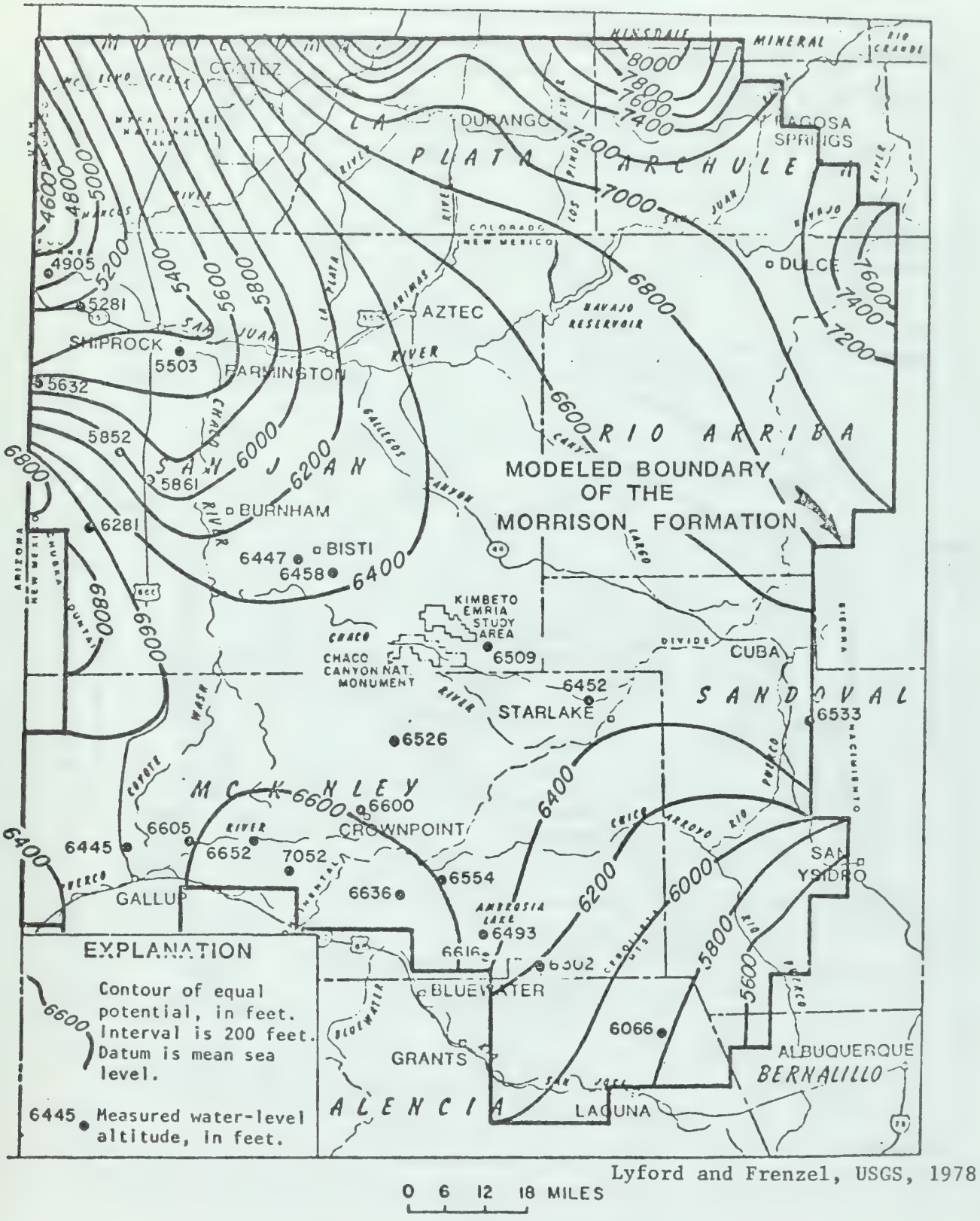
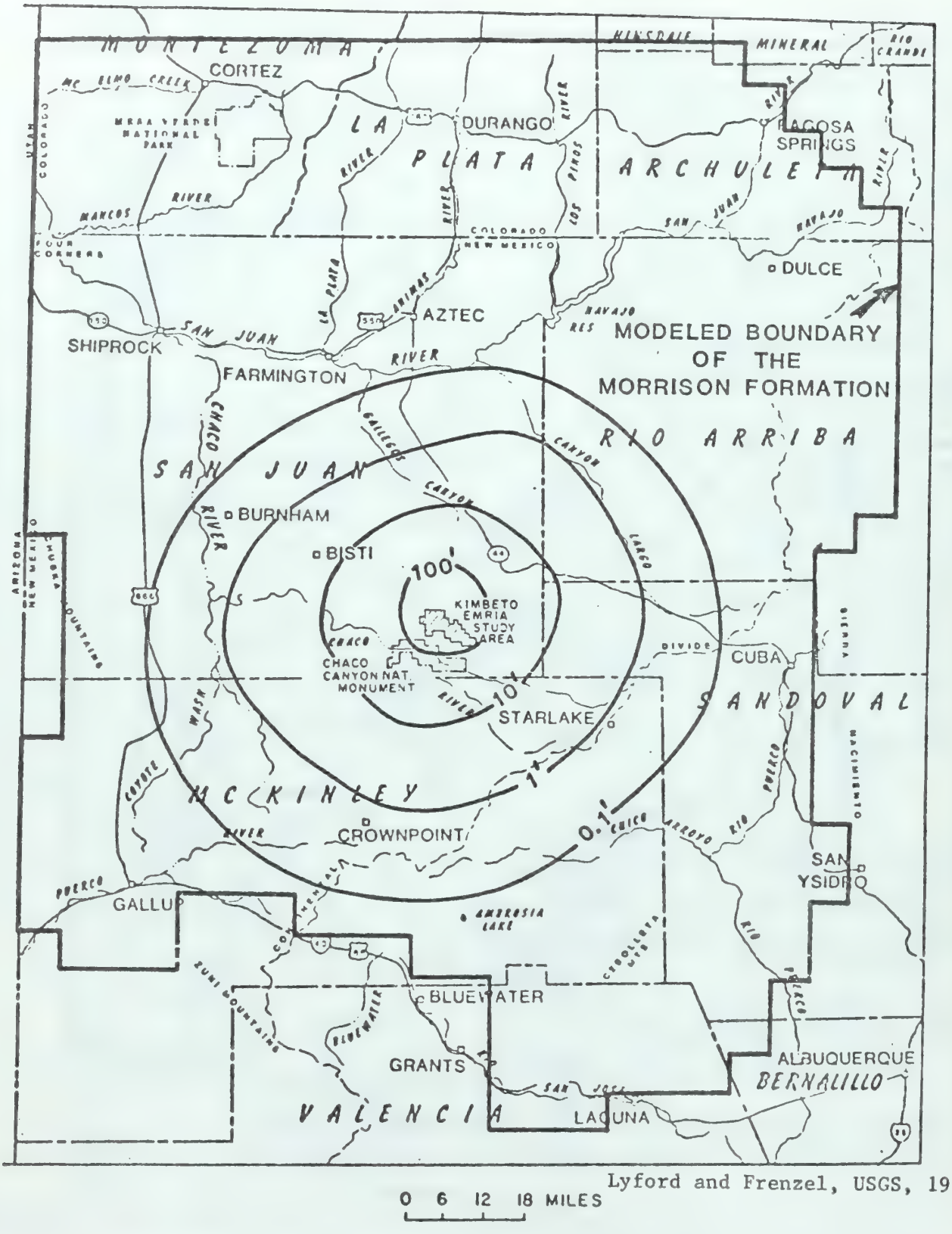
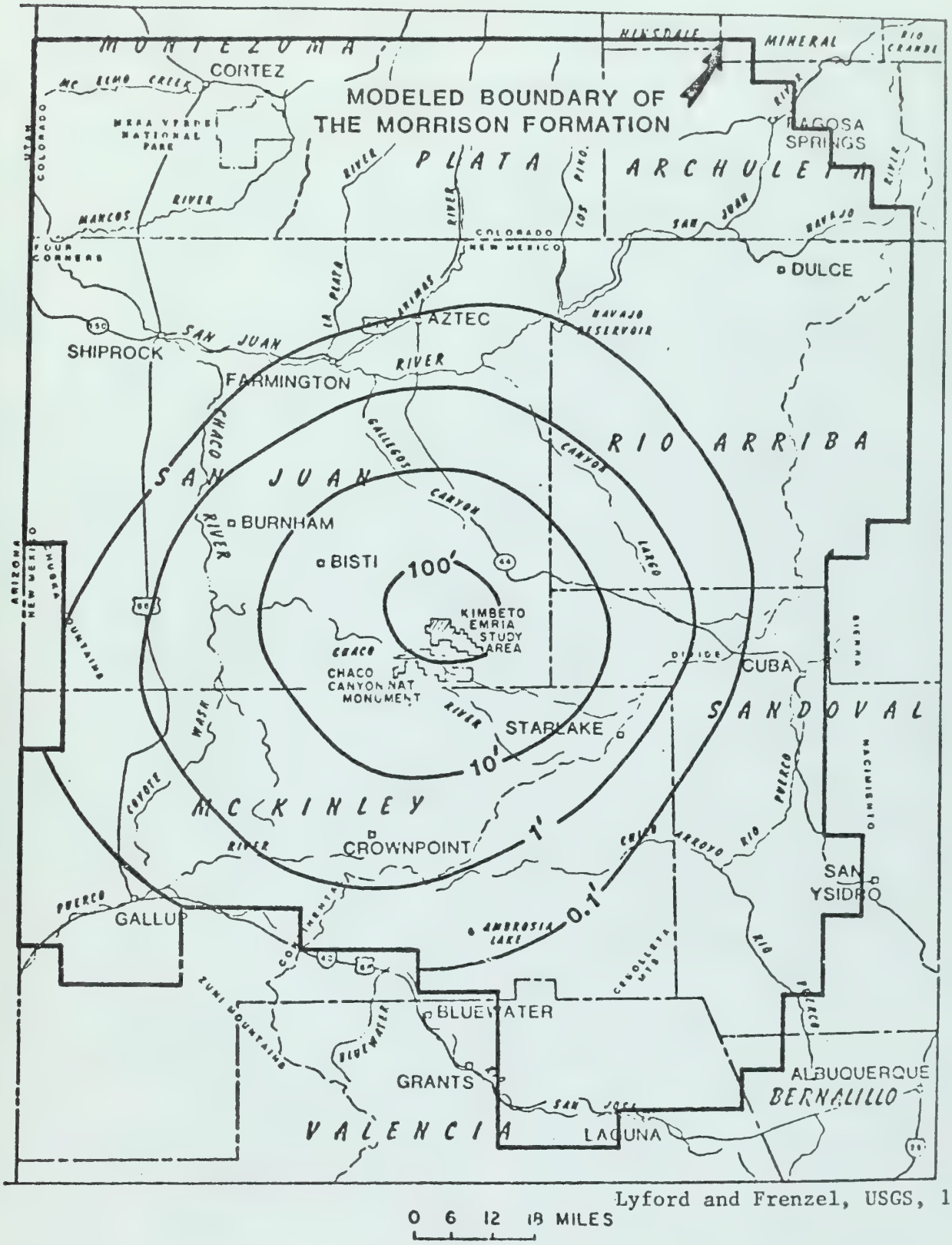


Figure S-3.--Modeled potentiometric surface for the Morrison Formation.



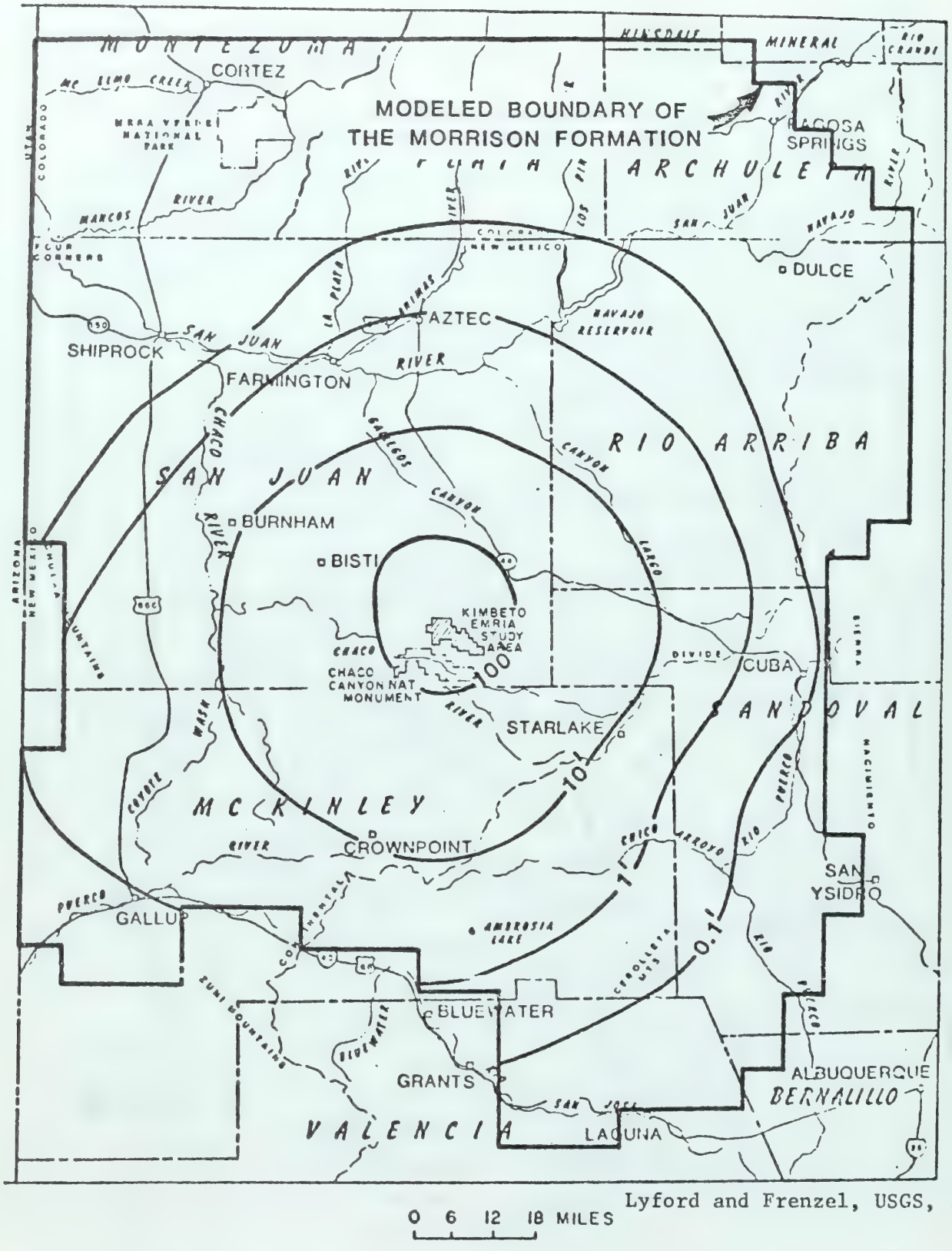
Lyford and Frenzel, USGS, 1978

Figure S-4.--Modeled drawdown, in feet, after pumping for 10 years at a rate of 400 gallons per minute, in the Morrison Formation at the Kimbeto EMRIA study area.



Lyford and Frenzel, USGS, 1978

Figure S-5.--Modeled drawdown, in feet, after pumping for 20 years at a rate of 400 gallons per minute, in the Morrison Formation at the Kimbeto EMRIA study area.



Lyford and Frenzel, USGS, 1978

Figure S-6.--Modeled drawdown, in feet, after pumping for 40 years at a rate of 400 gallons per minute, in the Morrison Formation at the Kimbeto EMRIA study area.

SECTION T

SELECTED GOVERNMENTAL COAL MINING REGULATIONS APPENDIX

SECTION T

SELECTED GOVERNMENTAL COAL MINING REGULATIONS APPENDIX

Federal Regulations

TITLE 43--PUBLIC LANDS, INTERIOR

CHAPTER II--BUREAU OF LAND MANAGEMENT,
DEPARTMENT OF THE INTERIOR

PART 3040--ENVIRONMENT AND SAFETY

SUBPART 3041--SURFACE MANAGEMENT

FEDERAL COAL RESOURCES

Section 3041.0-1 - Purpose

(a) The purpose of this subpart is to establish rules and regulations to be followed in the management of the federally owned coal estate consistent with the policies, goals, and objective established by the acts cited in section 3041.0-3 of this subpart, regardless of surface ownership, to assure effective and reasonable regulation of surface coal mining operations in accordance with the requirements hereof, as an appropriate and necessary means to minimize so far as practicable the adverse social, economic, and environmental effects of such operations.

(b) It is the policy of the Department to encourage the development of federally owned coal, where such development is authorized, through a program that will provide for the protection, orderly development, and conservation of Federal mineral and nonmineral resources in a manner that will avoid, minimize, or correct adverse impacts on society and the environment resulting from coal development, without undue duplication or administrative delay by Federal officers. It is also the policy of the Department to issue leases, permits, and licenses for coal only where reclamation of the affected lands to the standards set forth herein is attainable and assured and a reclamation program will be undertaken as contemporaneously as practicable with operations.

Section 3041.1-2 - Preliminary Data

(a) Any application for coal lease, permit, or license filed pursuant to the regulations in this chapter shall contain preliminary data (in lieu requirements also described).

(b) Such preliminary data shall include (1) maps of the topography of the land applied for; its physical features, roads, and utilities; and proposed exploration and mining operations and (2) a narrative statement covering

proposed exploration operations and mining method; existing land use; known geologic, visual, cultural, or archeological features; known habitat of fish and wildlife that may be affected by the proposed operations; and proposed measures to prevent environmental damage and public hazard and to reclaim the surface.

Section 3041.2-2 - Obligations and Standards of Performance

(a) Any operator who accepts a coal base, permit, or license shall comply with, and be bound by, the general obligations and standards of performance set forth in this section and such additional and more stringent specific requirements as may be contained in the terms and conditions of such lease, permit, or license.

(d) The operator shall take visual resources into account in the planning, design, location, and construction of facilities and shall take action to minimize, control, or prevent damage to the recreational, cultural, scientific, historical, and known or suspected archeological and paleontological values of the land.

(f) (1) The operator shall reclaim affected lands pursuant to his approved plan, as contemporaneously as practicable with operations, to a condition capable of supporting all practicable uses which such lands were capable of supporting immediately prior to any exploration or mining, or equal or better uses that have been approved in accordance with this subpart.

(2) The operator shall replace overburden and waste materials in the mined area by backfilling, grading, or other means, so as to cover all toxic materials and eliminate high walls and spoil piles and restore the approximate original contour. The operator shall use all available overburden or spoil material to obtain the lowest practicable grade, which shall in any event be less than the angle of repose. Excess overburden or other spoil material shall be fully reclaimed.

(3) The operator shall stabilize and protect all surface areas, including spoil piles, affected by the coal mining and reclamation operation, to effectively control slides, erosion, subsidence, and attendant air and water pollution.

(4) The operator shall remove topsoil separately, for replacement on the backfill area, and if not so utilized immediately, segregate it in a separate pile from other spoil. When topsoil is not to be replaced on a backfill area within a time short enough to avoid deterioration, the operator shall establish and maintain an approved quick growing vegetative cover or employ other approved measures so that the topsoil is protected from wind and water erosion and establishment of noxious plant species, and is in a condition for sustaining vegetation when used during reclamation. If topsoil is of insufficient quantity or of poor quality for sustaining vegetation, and if other excavated materials can be shown to be more suitable for revegetation, then the operator may be authorized in the approved plan to remove, segregate, protect, and utilize in a like manner such other materials.

(5) The operator shall assure that water impoundments, water retention facilities, dams, or settling ponds have been set forth in an approved plan, and are properly implemented.

(7) The operator shall utilize the best practicable commercially available technology to minimize, control, or prevent disturbances of the prevailing quality, quantity, and flow of water in surface and ground water systems, and of the prevailing erosion and deposition conditions at the mine site and in affected offsite areas, both during and after coal mining operations and reclamation.

(8) The operator shall properly treat or dispose of all rubbish and noxious substances and all waste resulting from the mining and preparation of coal in a manner designed to minimize, control, or prevent air and water pollution and the hazards of ignition and combustion.

(11) The operator shall design to applicable standards, construct, maintain, and, when no longer necessary and unless otherwise authorized in an approved plan, remove all roads, pipelines, powerlines, and similar utility access facilities and associated bridges, culverts, and ditches, into and across the site of operations, in a manner that will minimize, control, or prevent erosion and siltation, fugitive dust, pollution of water, damage to fish or wildlife or their habitat and public or private property.

(13) (i) The operator shall, except where other reclamation, based upon post-mining land use and not requiring revegetation pursuant to the requirements of this section, is expressly provided for in an approved plan, establish on regraded areas and all other affected lands a diverse vegetative cover native to the area and capable of regeneration and plant succession at least equal in density and permanence to the natural vegetation, provided, however, that the Mining Supervisor, with the concurrence of the appropriate authorized officer may allow the use of approved mixtures of introduced or native species where preferable to achieve quick cover or assure successful revegetation. In approving such mixture, preference will be given to nonnoxious species.

(ii) The operator's responsibility and liability under his performance bond for revegetation of each planting area shall extend until such time as the appropriate authorized officer, in consultation with the Mining Supervisor and the surface owner, if other than the United States, determines that successful revegetation in compliance with paragraph (i) of this subsection has occurred, provided, however, that this period shall extend for a minimum of 5 full years after the first planting, and for a total period of liability not to exceed 10 years from the original planting. (In certain instances this period of responsibility may not apply.)

(14) (ii) The operator shall regulate public access, vehicular traffic, and wildlife or livestock grazing in all areas of active operations, including lands undergoing reclamation, in order to protect the public, wildlife, and livestock

from hazards associated with such operations, and to protect revegetated areas from unplanned and uncontrolled grazing. For this purpose, the operator shall provide warning signs, fencing, flagmen, barricades, and other safety and protective measures as may be necessary.

Section 3041.5 - Completion of Operations and Abandonment

(a) Grading and backfilling. Upon completion of backfilling and grading as required by the approved plan and prior to replacing topsoil and revegetation, the operator shall submit a report thereon, in duplicate, to the Mining Supervisor and request inspection for approval. Whenever it is determined by such inspection that the backfilling and grading has met the requirements of the approved plan, the Mining Supervisor shall recommend to the appropriate authorized officer release of an appropriate amount of the compliance bond for the area satisfactorily backfilled and graded.

(c) Permanent abandonment. Methods of abandonment shall be approved in advance by the Mining Supervisor. Areas affected by access roads will be graded, drained, and revegetated in accordance with the approved Mining Plan and therein approved postmining land use prior to bond release. In the event that access or haul roads are intended to remain after abandonment of the operation, pursuant to section 3041.2-2(f)(11) of this subpart, they must be designed and constructed so as to be permanently stabilized using adequate drains, water barriers, and other practices.

TITLE 30--MINERAL RESOURCES

CHAPTER II--GEOLOGICAL SURVEY
DEPARTMENT OF THE INTERIOR

PART 211--COAL MINING OPERATING REGULATIONS

Section 211.75 - Applicability of State Law

(a) On the effective date of this part, and from time to time thereafter, the Secretary shall direct a prompt review of State laws and regulations in effect or adopted and due to come into effect, relating to reclamation of lands disturbed by surface mining of coal in each State in which Federal coal has been leased, permitted, or licensed. If, after such review, the Secretary determines that the requirements of the laws and regulations of any such State afford general protection of environmental quality and values at least as stringent as would occur under exclusive application of this Part, he shall, by rulemaking, direct that the requirements of such State laws and regulations thereafter be applied as conditions upon the approval of any proposed exploration or mining plan, unless (i) the Secretary determines that such application of the requirements of such laws and regulations would unreasonably and substantially prevent the mining of Federal coal in such State, and (ii) the Secretary determines that it is in the overriding national interest that such coal be produced without such application of such requirements. In any such determination of overriding national interest, the Secretary will consult in advance of such determinations with the Governor of the State involved.

CHAPTER VII--OFFICE OF SURFACE MINING
RECLAMATION, AND ENFORCEMENT

DEPARTMENT OF THE INTERIOR

PART 700-GENERAL

Section 700.1--Scope

(a) This chapter sets forth the rules and procedures through which the Secretary of the Interior will implement the Surface Mining Control and Reclamation Act of 1977 (Pub. L. 95-87). The Act requires the Secretary to establish procedures for development and approval of programs for the regulation of surface coal mining and surface effects of underground coal mining in each State. The Act also requires the Secretary to establish an initial regulatory program which applies limited environmental performance standards to State, Federal, Indian and private lands until the implementation of a permanent regulatory program.

(b) Regulations authorized under Act and contained in this chapter include but are not limited to . . . .

(1) Environmental performance standards for surface coal mining and reclamation operations during the initial and permanent regulatory programs, including the assessment of civil penalties;

(2) Inspection and enforcement procedures during initial and permanent regulatory programs, including the assessment of civil penalties;

(3) Assistance to small operators meeting permit application requirements of the permanent regulatory program;

(4) Requirements and approval procedures for State programs;

(5) Requirements for surface coal mining and reclamation operations on Federal lands;

(6) Procedures for State and Federal designation of areas unsuitable for surface coal mining operations and lands unsuitable for non-coal mining;

(7) Conflict of interest standards for State and Federal employees;

(8) Requirements and procedures for approval of State mining permits during the permanent regulatory program;

(9) Requirements for posting, release and forfeiture of performance bonds;

(10) Standards prohibiting discrimination against employees for reporting violations of the Act and regulations;

(11) Procudures for administering the Abandoned Mine Reclamation Fund, including approval of State plans and programs, procedures for implementing Federal programs; and

(12) Procedures for grants for State mining and mineral research institutes.

State Regulations

Section 1 - Permit Application - Fees

A permit application accompanied by a written mining plan and signed by the operator shall be filed with the Director of the State Bureau of Mines and Mineral Resources along with the application and initial acreage fees required by Subparagraphs 1 and 2, Subsection A, Section 7, of the New Mexico Coal Surfacemining Act, Chapter 68, Laws 1972, hereinafter referred to as "the Act." Duplicates of the application and mining plan shall be filed with the Director of the Environmental Improvement Agency.

Section 2 - Mining Plan

The mining plan prepared by the operator for approval by the Commission shall set forth the following information:

F. Topographical maps showing drainage before, during, and after mining.

G. Physiography before and after mining.

H. Present and future land use of study site and pertinent surrounding land.

I. Summay of climatological, topographical, soil, water, agricultural, wildlife, and other data pertinent to current and future land use of study site.

J. Water to be stored, diverted, or used and resulting pollutants.

K. Description and analyses of soils in the area to be mined.

O. Existing depth of topsoil in affected area.

P. Proposed efforts to remove and preserve topsoil during mining.

R. Description of existing and postmining vegetation, planting times, and times for growth to maturity.

S. Detailed proposal and time schedule for revegetation.

V. Plans for disposal of waste materials.

Section 5 - Grading

A. Grading shall proceed as set out in the operator's mining plan. Grading shall be an integral part of the mining operation and shall be completed within a reasonable and prescribed time limit.

B. Grading shall be carried out so as to produce a greatly undulating topography or such other topography as is consistent with the proposed end use of the area stated in the approved mining plan.

C. Grading shall be done in such a manner as to control erosion and siltation of the affected area, surrounding property, and water courses.

D. Mining and grading shall not affect the drainage or streamflow in a manner that would impair or be detrimental to existing water rights or the availability of water for beneficial use in the State.

E. The operator shall grade the affected area, construct earth dams in final cuts of all operations, or take whatever measures are necessary to control water which is sufficiently toxic to be dangerous or harmful to or destructive of plant, animal, or human life; provided that a dam may be constructed in a final cut only if such construction and impoundment would not be contrary to the water laws of this State.

F. Where waste material is to be deposited within the affected area, such deposits shall be in such designated areas and within such schedules as are set forth in the approved mining plan and shall be covered to a minimum depth as set forth in the approved mining plan. The operator shall commence grading and reclamation of that portion of the affected area to be used to deposit waste material immediately after cessation of the depositing of waste material.

G. Grading of access, haul or support roads, and final cuts as shown in the mining plan may be excepted of deferred, with the approval of the Commission. Final cuts whose grading is to be excepted or deferred, must be graded, to the extent necessary, upon the order of the Commission if the Commission determines that the ungraded final cut is (1) interfering with drainage or forming pools detrimentally affecting existing water rights or the availability of water for beneficial use in the State, or (2) leaving a condition which may cause a loss of coal resource by fire or excessive oxidation.

Section 6 - Revegetation

A. Revegetation shall proceed as set out in the operator's approved mining plan. Revegetation shall be an integral part of the mining operation, shall be carried out to the extent practicable in consultation with the local soil and water conservation district, and shall be completed within a reasonable and prescribed time limit.

B. The operator shall revegetate the affected area in the following manner for the appropriate end use stated in the operator's mining plan:

(1) Forest planting - The type of trees to be planted shall be as set forth in the approved mining plan. In passing upon the type of trees to be planted, the Commission shall consider the character and nature of the soil, the altitude, the temperature, and the precipitation at the site. Planting methods and care of planting stock shall be governed by professionally accepted reforestation practices.

(2) Range - The vegetative species to be planted or seeded shall be as set forth in the approved mining plan. The character and nature of the soil, the natural rainfall and the intended capacity of the area for grazing by livestock following the stripmining activity shall be considered by the commission in passing on the operator's selection.

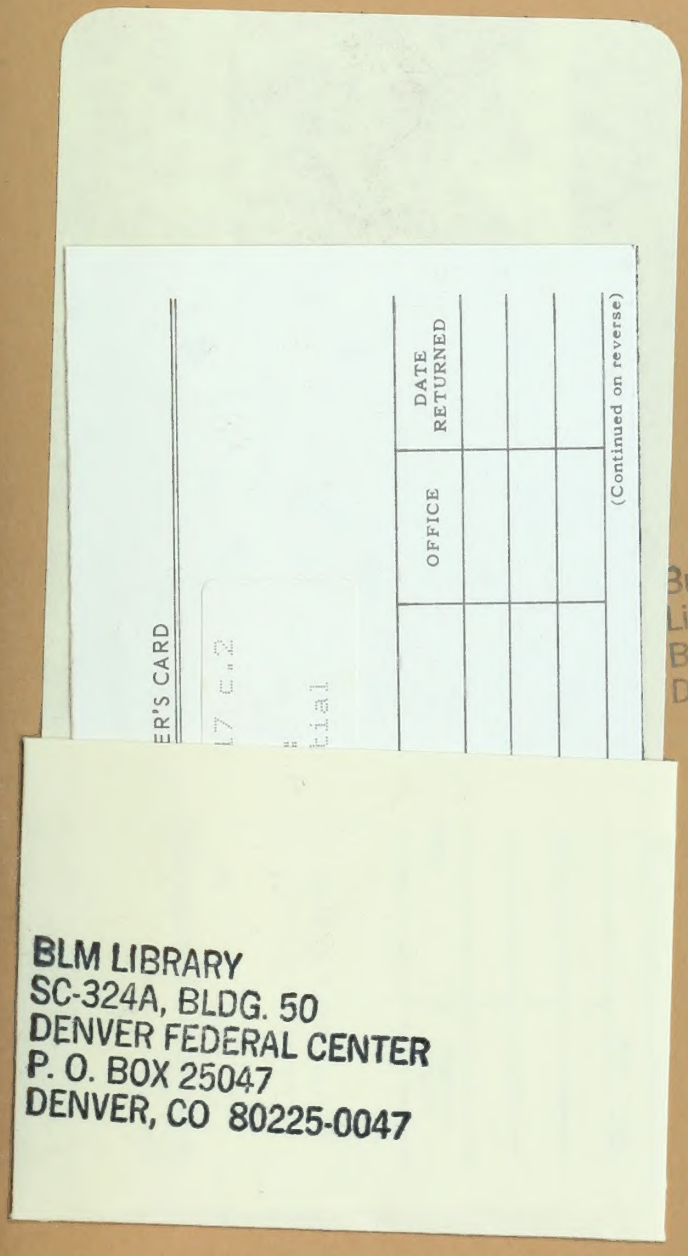
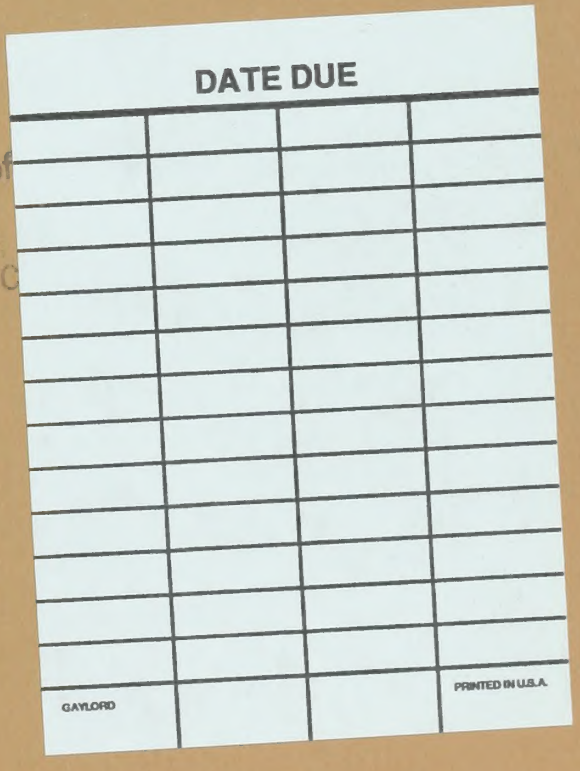
(3) Agricultural or Horicultural Crops - Seeding plans and planting rates shall be set forth in the approved mining plan.

(4) Special Projects - Affected areas to be developed for selected purposes such as recreational, residential, industrial, or other special uses shall have a reclamation program suitable for the specific use set forth in the approved mining plan.

C. The operator, with the consent of the Commission, may delay planting or seeding the affected area during any period in which the operator is conducting research on more productive methods of revegetation.

D. Revegetation of haulage roads shall not be required where the road has been adequately surfaced and the operator or owner of the property has demonstrated to the satisfaction of the Commission that the roads will be required for a substantial use after stripmining operations have terminated.

E. Upon application by the operator concerning any portion of affected area, the Commission shall investigate whether the operator has completed the reclamation set forth in the approved mining plan or if, considering the natural condition and vegetation prior to stripmining, technical and economic practicability, future productivity for the end use stated in the approved mining plan, esthetic appearance and peculiar condition of the geographic area in which the stripmine is located, further revegetation efforts are justified. If the Commission shall determine that the reclamation set forth in the mining plan has been completed or that further revegetation efforts are not justified, it shall certify such decision to the operator and he shall thereupon be released from further reclamation duties with respect to the portion of affected area concerned, including any bond relating thereto.



Bureau of
Library
Bldg. 50,
Denver, C